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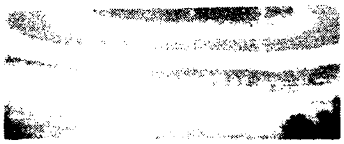

HYDRAULICS LABORATORY

FLOOD CONTROL RESEARCH PROGRAM

MISCELLANEOUS PAPER HL-91-3

RIPRAP STABILITY TESTS IN LARGE TILTING FLUME

by

Civil Engineering Department
Engineering Research Center
Colorado State University
Fort Collins, Colorado 80523

June 1991
Final Report

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This collection of four reports presents results of riprap stability studies conducted in the 8-ft-wide tilting flume for the US Army Corps of Engineers at Colorado State University, Fort Collins, CO. The first three reports address stability of riprap on the bottom of the tilting flume using riprap having a wide range of thicknesses and gradations. The fourth report addresses the stability of riprap placed on a 1V:2H side slope. Vertical velocity profiles were obtained at several positions across and along the flume to document flow conditions for both stable and failure conditions. Water-surface profile data were obtained to establish slopes and channel depths along the flume.

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PREFACE

The four studies reported herein were performed at Colorado State University (CSU), Fort Collins, CO, under contract to the US Army Engineer Waterways Experiment Station (WES) during the period 1982 to 1987. This investigation was sponsored by the Headquarters, US Army Corps of Engineers (USACE), as part of Civil Works Investigation Work Unit No. 31028, "Effects of Water Flow on Riprap in Flood Channels," under USACE Program Monitor Mr. Tom Munsey.

This investigation was accomplished under the direction of Messrs. H. B. Simmons, former Chief of the Hydraulics Laboratory, WES; F. A. Herrmann, Jr., Chief of the Hydraulics Laboratory; J. L. Grace, Jr., former Chief of the Hydraulic Structures Division, Hydraulics Laboratory; and G. A. Pickering, Chief of the Hydraulic Structures Division. The Contracting Officer's Representative was Dr. S. T. Maynord, who was under the direct supervision of Mr. N. R. Oswalt, Chief of the Spillways and Channels Branch, Hydraulic Structures Division.

Commander and Director of WES during preparation of this report was COL Larry B. Fulton, EN. Technical Director was Dr. Robert W. Whalin.

CONTENTS

STABILITY TESTS OF RIPRAP
IN
FLOOD CONTROL CHANNELS

prepared for

U.S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, Mississippi

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Civil Engineering Department
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Fort Collins, Colorado
October 1982

CER81-82AAF-YHC-DBS56

FOREWORD

This study was performed under a contract titled "Stability Tests of Riprap in Flood Control Channels" between the U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, and Colorado State University. This report includes the tabulated and mapped data collected during the study, as well as analysis of the major results. The study plan and program was coordinated between WES and CSU by Mr. Stephen T. Maynord of WES. The investigation was conducted by Dr. Abbas A. Fiuzat of the Civil Engineering Department, Colorado State University, with supervision and technical advice of Dr. Yung Hai Chen, Associate Principal Engineer, Simons, Li and Associates Inc., Fort Collins, Colorado, and Dr. Daryl B. Simons, Professor of Civil Engineering, Colorado State University. Valuable technical suggestions were also provided by Dr. Johannes Gessler, Associate Professor of Civil Engineering, Colorado State University. Mr. Keith D. Engell and Mr. Kevin L. Murphy assisted in conducting the study. The study period was August 1981 to February 1982. This report was typed by the Technical Typing staff of the Engineering Research Center, Foothills Campus, Colorado State University.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

INTRODUCTION

1.1 Background

The study of riprap stability at Colorado State University was a supplement to previous studies conducted at the U.S. Army Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi. The facilities of the Hydraulics Laboratory, Engineering Research Center, Colorado State University allow the use of larger flow rates and velocities, variable channel slopes, and larger sizes of riprap than used in previous studies. This study was necessary in order to provide a comprehensive picture of the incipient motion of riprap material and to provide criteria for designing stable riprap surfaces for erodible channel beds.

1.2 Objectives and Conditions of the Study

A proposal was prepared in agreement with WES to study three sizes of riprap, namely 3/4-inch, 2-inch, and 3-inch median size. A constant gradation for all three sizes was to be used, as shown in Figure 1.1. Each riprap size was tested under four flow rates, namely, 25, 50, 75, and 100 cfs. For each flow rate the flume slope was increased at prescribed increments (section 2.2), until failure of the riprap surface and exposure of the underlying filter blanket was observed. The slope was then reduced one step and the same flow rate routed for a prolonged time (3-4 hours) to make sure that the riprap was stable. The testing procedures and the data collection program are explained in Section 2.5. The tests were arranged such that criteria for incipient motion of riprap material could be determined.

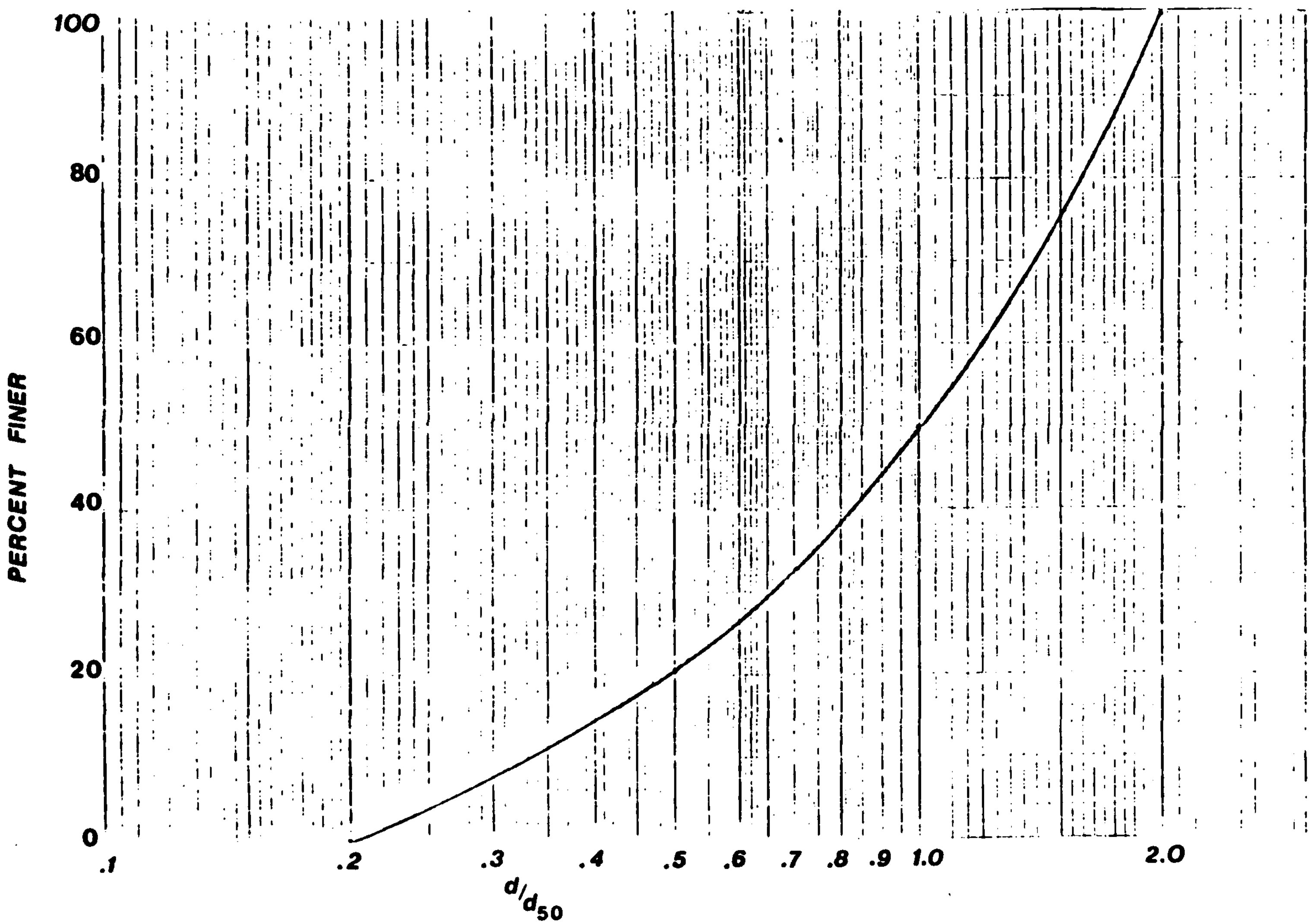

Figure 1.1. Standardized Riprap Gradation

The experimental program, data analysis, and discussion of the results are presented in Chapters 2, 3, and 4 of this report. The concluding chapter summarizes the work, presents major conclusions, and contains recommendations for further studies in relation to this subject. All the test data are presented in the appendix.

Chapter 2

EXPERIMENTAL PROGRAM

2.1 Experimental Setup

The riprap stability tests were conducted in the 8-ft flume in the Hydraulics Laboratory at the Engineering Research Center, Colorado State University. The flume is 8 ft wide, 4 ft deep and 200 ft long. The flume is made primarily of aluminum sides and bottom. A portion of the side of the flume is made by Plexiglas to allow observation of the section under study. The flume slope can be adjusted from 0 to 2 percent. One 250-hp pump and two 150-hp pumps can generate a total discharge of 100 cfs. Two gates installed at the downstream end of the flume allow the control of water level in the flume under subcritical flow conditions. A motorized carriage can travel along the flume for carrying data collection instruments and photographic equipment. A schematic diagram of the flume and the test section are shown in Figure 2.1.

The 80-ft flow development section was utilized to create a sufficiently developed turbulent flow entering the test section. The surface of the 20-ft transition section consisted of rocks similar to those of flow development section in the upstream end, gradually decreasing in size to those of the riprap section. The purpose of the transition section was to eliminate the abrupt change in roughness between the flow development section and the test section. Construction of the riprap surface is explained in Section 2.4.

Downstream of the test section the flume bottom was raised four inches because the drop from the riprap surface to the original flume bottom created high velocities at the downstream end of the test section

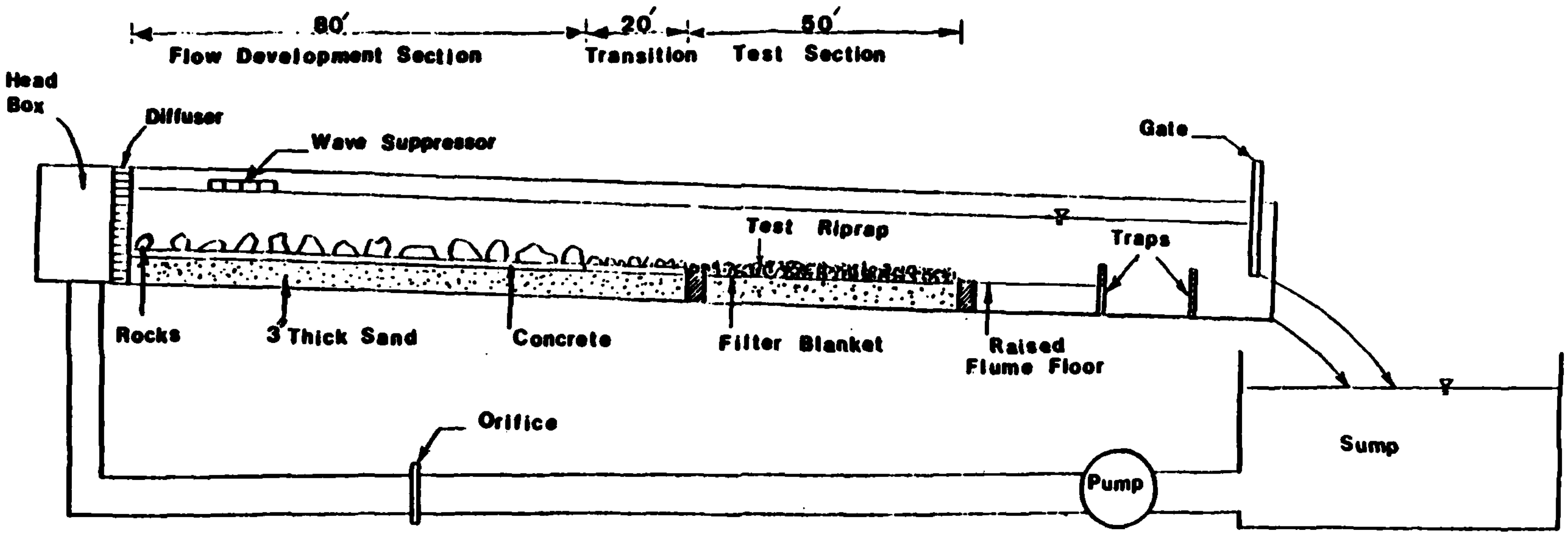

Figure 2.1. The Experimental Setup

and caused undesirable flow conditions. Two traps downstream of the test section collected all the washed material for the necessary size analysis.

2.2 Development of the Range of Testing Conditions

The primary objective of this study was to test various sizes of riprap under different flow conditions to evaluate riprap stability. The test data were analyzed to determine if the Shields coefficient is a constant under varying conditions of discharge and riprap size, and if so, what is the most suitable value of the coefficient to be used for design of riprap. For planning the experimental program, the ranges of testing conditions were determined for the Shields coefficient varying from 0.025 to 0.060, assuming that incipient motion of riprap would occur at a value of Shields coefficient within this range. The Shields coefficient, C, is defined as

$$C = \frac{\tau}{(\gamma_s - \gamma_w)\ d_{50}} \tag{2.1}$$

where τ is boundary shear stress, γ_s and γ_w are the specific weights of rock and water respectively, and d_{50} is the median size of riprap. Replacing τ with γRS and simplifying, Equation 2.1 becomes

$$C = \frac{RS}{(s - 1)\ d_{50}} \tag{2.2}$$

where R is the hydraulic radius, S is the slope, and s is the specific gravity of the rock. For developing the test conditions the hydraulic radius is replaced with flow depth D to obtain

$$C = \frac{DS}{(s - 1)\ d_{50}} \tag{2.3}$$

Values of d_{50} were specified for the study, so for each size the values of D and S have to be determined to obtain the desired Sheilds coefficient. Manning's equation was used for this purpose:

$$Q = \frac{1.49}{n} W D R^{2/3} S^{1/2} \tag{2.4}$$

where Q is the discharge, n is Manning's roughness factor, and W is the flume width. Again, the hydraulic radius R was approximated with the depth D, so Equation 2.4 becomes

$$Q = \frac{1.49}{n} W D^{5/3} S^{1/2} \tag{2.5}$$

From Equation 2.3

$$D = \frac{C(s - 1) d_{50}}{S} \tag{2.6}$$

and substituting in Equation 2.5

$$Q = \frac{1.49}{n} W [C(s - 1) d_{50}]^{5/3} S^{-7/6}$$

or

$$S = [\frac{1.49W}{nQ}]^{6/7} [C (s - 1) d_{50}]^{10/7} \tag{2.7}$$

The locally available materials have a specific gravity, s, of 2.65 and the test flume has a width of 8 ft. Substituting these values in Equation 2.7 yields

$$S = 17.07 (nQ)^{-6/7} (C d_{50})^{10/7} \tag{2.8}$$

Values of d_{50} and Q have been specified for the tests. Therefore, for each desired value of C the corresponding slope can be determined from Equation 2.8. Values of the Manning's roughness factor were estimated from Strickler's equation

$$n = \frac{d_{90}^{1/6}}{26} \tag{2.9}$$

However, preliminary tests showed that the actual roughness of the surface is about 20 percent more than what Strickler's equation indicates. After determining the flume slope, the expected flow depth was found from Equation 2.6, and the expected velocity from Manning's equation

$$V = \frac{1.49}{n} D^{2/3} S^{1/2} \tag{2.10}$$

Tables 2.1, 2.2, and 2.3 show the ranges of testing conditions.

2.3 Mixing Procedures and Preparation of Riprap Material

Knowing the dimensions of the test section, the volume of the required riprap material and hence the weight of material for each size could be readily determined. The gradation curve, as shown in Figure 1.1 specifies that the riprap should not contain any particles larger than 2 d_{50} or smaller than 0.2 d_{50}. So, depending on the availability of local materials and ease of obtaining or manufacturing sieve sizes, the range between 0.2 d_{50} and 2 d_{50} of each riprap size was divided into 4 to 6 intervals. The weight of material for each interval was determined from Figure 1.1 and the total required test riprap. The materials were then weighed according to the calculations and mixed together. The amount of work and expenses were minimized by resieving part of the tested riprap and using the material for the next riprap size.

Sieving was done by hand for the larger sizes. A set of flat sieves were manufactured from 2 to 6 inches in size. Material was dumped on the smallest sieve and moved by hand onto the larger sieves.

Table 2.1. The Range of Testing Conditions for the 3/4-inch Riprap.

C	Q = 25 cfs			Q = 50 cfs			Q = 75 cfs			Q = 100 cfs		
	S	D ft	V fps	S	D ft	V fps	S	D ft	V fps	S	D ft	V fps
0.025	0.00240	1.072	2.91	0.00133	1.943	3.22	0.00094	2.750	3.41	0.00073	3.519	3.55
0.030	0.00312	0.992	3.15	0.00172	1.797	3.48	0.00122	2.543	3.69	0.00095	3.255	3.84
0.035	0.00389	0.928	3.37	0.00215	1.682	3.72	0.00152	2.381	3.94	0.00118	3.047	4.10
0.040	0.00470	0.877	3.56	0.00260	1.588	3.93	0.00183	2.248	4.17	0.00143	2.877	4.34
0.045	0.00557	0.834	3.75	0.00307	1.510	4.14	0.00217	2.138	4.39	0.00170	2.736	4.57
0.050	0.00647	0.797	3.92	0.00357	1.443	4.33	0.00252	2.043	4.59	0.00197	2.615	4.78
0.055	0.00741	0.765	4.09	0.00409	1.386	4.51	0.00289	1.962	4.78	0.00226	2.510	4.98
0.060	0.00840	0.737	4.24	0.00463	1.335	4.68	0.00327	1.890	4.96	0.00256	2.418	5.17

d_{50} = 0.75 in = 0.0625 ft,
d_{90} = 1.32 in = 0.0335 m,
and n = 0.0262

Table 2.2. The Range of Testing Conditions for the 2-inch Riprap

	Q = 25 cfs			Q = 50 cfs			Q = 75 cfs			Q = 100 cfs		
C	S	D ft	V fps	S	D ft	V fps	S	D ft	V fps	S	D ft	V fps
0.025	0.00852	0.808	3.86	0.00470	1.465	4.27	0.00332	2.073	4.52	0.00260	2.653	4.71
0.030	0.01106	0.741	4.18	0.00610	1.354	4.61	0.00431	1.917	4.89	0.00337	2.454	5.09
0.035	0.01378	0.670	4.46	0.00761	1.268	4.93	0.00537	1.795	5.22	0.00420	2.297	5.44
0.040	0.01667	0.661	4.73	0.00921	1.197	5.22	0.00650	1.695	5.53	0.00508	2.169	5.76
0.045	0.01973	0.628	4.97	0.01089	1.138	5.49	0.00769	1.612	5.82	0.00601	2.062	6.06
0.050				0.01266	1.088	5.74	0.00894	1.540	6.09	0.00699	1.971	6.34
0.055				0.01451	1.045	5.98	0.01025	1.479	6.34	0.00801	1.892	6.61
0.060				0.01643	1.006	6.21	0.01161	1.425	6.58	0.00907	1.823	6.86

d_{50} = 2.0 in = 0.167 ft,
d_{90} = 3.52 in = 0.0897 m, and
n = 0.0308.

Table 2.3. The Range of Testing Conditions for the 3-inch Riprap

C	Q = 25 cfs			Q = 50 cfs			Q = 75 cfs			Q = 100 cfs		
	S	D ft	V fps	S	D ft	V fps	S	D ft	V fps	S	D ft	V fps
0.025	0.01429	0.722	4.33	0.00789	1.307	4.78	0.00557	1.850	5.07	0.00436	2.368	5.28
0.030	0.01854	0.667	4.68	0.01024	1.209	5.17	0.00723	1.711	5.48	0.00565	2.190	5.71
0.035				0.01276	1.132	5.52	0.00901	1.602	5.85	0.00704	2.050	6.10
0.040				0.01544	1.069	5.85	0.01091	1.513	6.20	0.00852	1.936	6.46
0.045				0.01827	1.016	6.15	0.01291	1.438	6.52	0.01009	1.840	6.79
0.050				0.02124	0.971	6.44	0.01500	1.375	6.82	0.01172	1.759	7.11
0.055							0.01719	1.320	7.10	0.01343	1.689	7.40
0.060							0.01947	1.271	7.37	0.01521	1.627	7.68

d_{50} = 3.0 in = 0.25 ft,
d_{90} = 5.28 in = 0.134 m, and
n = 0.0330.

Material larger than 6 inches was piled together for use in the approach section. Only for the 3/4-inch riprap, the smallest size interval material was purchased and used without sieving. This material contained some sizes finer than 0.2 d_{50}, but their effect on the performance of the riprap was assumed to be negligible.

After each riprap mixture was prepared, a size analysis was conducted to determine how close the actual gradation was compared to the design gradation of Figure 1.1. For the 3/4-inch riprap, the analysis was done by the traditional sieve-set and weighing method. For the 2- and 3-inch ripraps the analysis was done by the photographic method, where a 2 x 2-ft frame divided into 0.1 ft grids was placed on the riprap surface and photographed. By finding the area occupied by each rock size group a gradation curve equivalent to the weighing method was obtained. The results of particle size distribution analyses of the original riprap mixtures are shown in Figure 2.2 and Table 2.4.

Table 2.4. Gradation of the Riprap Material

Design d_{50} inches	Design Graduation		Actual d_{50} inches	Actual Graduation	
	d_{84}/d_{50}	d_{50}/d_{16}		d_{84}/d_{50}	d_{50}/d_{16}
3/4	1.65	2.35	3/4	1.49	3.23
2	1.65	2.35	1.87	1.49	1.85
3	1.65	2.35	3.0	1.60	2.33

2.4. Construction of the Riprap Surface

The test riprap surface was prepared according to the original study proposal. A 3-inch layer of plaster sand (d_{50} = .57 mm) was placed on the bottom of the flume. A layer of Typar filter blanket (made by DuPont) was then placed on the sand surface and secured to the

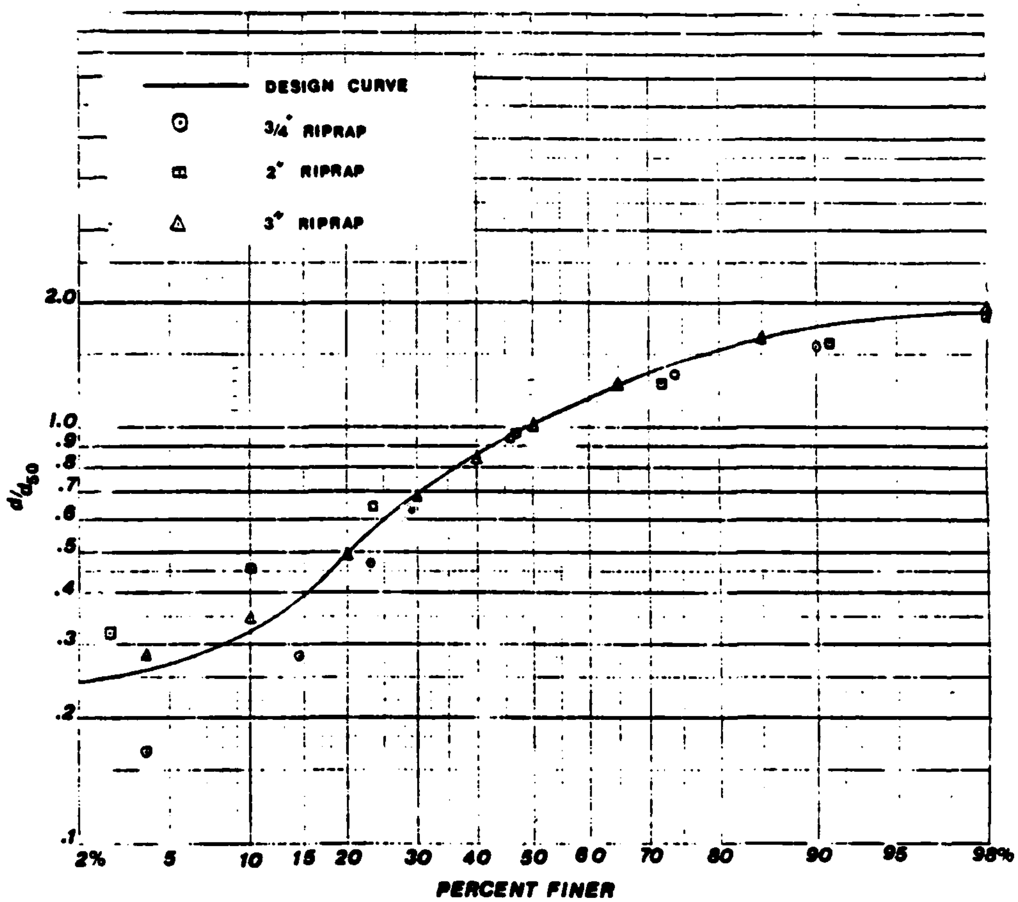

Figure 2.2. Standardized Size Distribution of the Riprap Mixtures

flume by wooden supports and plaster laths on all four sides. The riprap was dumped on the filter blanket at a thickness of 2 d_{50} without further touching or reorienting. The transition section was also reconstructed for each riprap size. This section was similar to the test section in construction, except that a layer of concrete was used instead of the filter blanket. Larger material was dumped at the upstream side of the transition section and gradually finer material was dumped toward the downstream side. The material would be embedded partially in the concrete, so that water could not dislodge them and wash them out. The joint between the transition section and test section was very smooth. The flow development section was built following a procedure similar to preparing the transition section, with large, fairly uniform sizes of rocks and was not altered for the entire course of the study.

2.5 *Testing Procedure and Data Collection Program*

The order of testing was arranged from the smallest to the largest size of riprap and from the smallest to the largest flow rate for each size. After placing each riprap size, a suitable value of the Shields coefficient, C, was chosen from Tables 2.1 to 2.3 and the flume slope was adjusted accordingly. The value of C was usually chosen small enough so that no washout would be observed in the first run. The desired discharge was then routed. The starting depth of flow was maintained at a value larger than uniform flow depth (Tables 2.1-2.3). By gradually opening the tailwater gate the depth was reduced until uniform flow occurred on the test section. This procedure eliminated the possibility of washing the riprap due to nonuniform flow conditions.

The test was continued for 2 hours after establishing uniform flow. During this time flow depths were measured at the flume midpoint in 3 stations: 10 ft, 25 ft, and 40 ft from the beginning of the test section. Velocities were simultaneously measured by a current meter at the same sections in two vertical positions: 0.2 D and 0.8 D from the water surface. These data were used to find the average velocity and average depth of flow at the test section.

The discharge was measured by orifices installed in the pipes conveying water from the pumps to the head box. The differential head across the orifice was measured by water or mercury manometers depending on the discharge. The manometer readings were checked several times during each test to make sure a constant discharge was being routed. However, some variation in discharge could exist due to fluctuating manometers. The water temperature was also measured and recorded.

After each test, if no washout of the riprap was observed, the flume slope was increased to obtain a higher value of the Shields coefficient, according to Tables 2.1-2.3. Similar procedures were followed until the conditions produced riprap failure. At this time the washed riprap which was collected behind the traps (Figure 2.1) were analyzed for size distribution. The locations and sizes of the washout areas on the riprap surface were also mapped and recorded. The riprap surface was then repaired by dumping new sediment, the flume slope was reduced to one step less than the failure slope (Tables 2.1-2.3) and the discharge was routed again. The test under these conditions was carried out for 4 hours to make sure the riprap was stable.

Data for these tests were collected more extensively at stations 10 ft, 25 ft, and 40 ft from the beginning of the test section. At each

station, 3 verticals were used for measuring the depth, namely at 0.17 W, 0.50W, and 0.83 W across the section. Velocities were measured on each vertical at 5 positions, namely, at 0.1, 0.3, 0.5, 0.7, and 0.9 D from the water surface. Thus, 9 depths and 45 velocities were measured. Discharge and temepratture were also measurd and recorded as before. If under these conditions riprap failure did again occur, the slope was reduced another step and similar procedures were followed. If riprap failure was not observed, these conditions were assumed to be the incipient motion conditions for the riprap under test and for the discharge being routed. The collected data are tabulated and attached in the Appendix.

2.6 Summary of the Test Conditions

Based on the testing conditions and procedures, a total of 48 acceptable runs were conducted. The summary of the test conditions is presented in Table 2.5. If during a test insufficient control of flow and nonuniform flow conditions were observed, the results of the test were discarded.

Table 2.5. Summary of the Test Conditions

Riprap size inches	Orifice discharge cfs	Run no.	Flume slope	Area washed sq. ft.	Water temperature °F
.75	25	1	0.00312	-	70
		2	0.00470	1.6	70
		3	0.00470	0.1	75
		4	0.00557	0.7	79
		5	0.00389	0.5	80
	50	6	0.00133	-	80
		7	0.00215	-	80
		8	0.00307	38.0	80
		9	0.00260	25.0	69
		10	0.00215	4.0	73
	75	11	0.00094	-	75
		12	0.00152	-	75
		13	0.00217	40.0	75
		14	0.00183	12.0	75
		15	0.00152	1.4	75
	100	16	0.00095	-	75
		17	0.00143	9.7	75
		18	0.00118	5.0	77
		19	0.00095	-	77
1.78	25	1	0.00852	-	78
		2	0.01378	-	78
		3	0.01667	4.0	75
		4	0.01973	-	75
	50	5	0.00761	-	75
		6	0.01089	-	70
		7	0.01451	89.0	70
		8	0.01266	40.0	68
		9	0.01089	2.5	68
	75	10	0.00537	-	70
		11	0.00769	-	70
		12	0.01025	17.0	70
		13	0.00894	6.0	72
		14	0.00769	-	70
	100	15	0.00420	-	70
		16	0.00601	-	70
		17	0.00801	33.0	75
		18	0.00699	4.0	75
		19	0.00601	-	75

Table 2.5. (continued)

Riprap size inches	Orifice discharge cfs	Run no.	Flume slope	Area washed sq. ft.	Water temperature °F
3.0	25	1	0.02000	-	70
	50	2	0.01544	-	70
		3	0.02000	-	70
	75	4	0.01500	4.0	68
		5	0.01719	15.0	68
		6	0.01500	3.5	72
		7	0.01291	-	68
	100	8	0.01009	-	70
		9	0.01343	10.0	72
		10	0.01172	0.2	68

Chapter 3

DATA ANALYSIS

Analysis of the collected data was performed at several stages. Part of the analyzed data were provided to WES in previous correspondence. It was found through those analyses that best results are obtained by finding average depths and velocities using the entire data obtained for each run. Specifically, such averaging eliminates the effects of surface waves which were present in almost every run. The complete set of collected data are attached in the appendix to this report for reference or additional analysis.

3.1 Development of Basic Equations and Method of Analysis

The analysis of data as presented through the rest of this chapter were performed utilizing the following equations and methods. Froude number is calculated from

$$F = \frac{V}{\sqrt{gD}} \tag{3.1}$$

where V and D are average velocity and depth for each run, and g is the gravitational acceleration. The difference between wall and bed roughness has no effect on the calculated Froude number and the average depth used in Equation 3.1 is adequate.

To calculate Manning's roughness factor, n, the difference between the smooth walls and the rough bed should be considered. The flow cross-sectional area in this case is divided into two parts, A_b and A_w where resistance to flow is caused by the bed and the walls respectively. It is assumed that the mean velocity and energy gradient are the same for A_b and A_w and Manning's equation can be applied to each part of the cross-section as well as to the whole, i.e.,

$$\frac{V^2}{S} = \left(\frac{1.49}{n} R^{2/3}\right)^2 = \left(\frac{1.49}{n_b} R_b^{\ 2/3}\right)^2 = \left(\frac{1.49}{n_w} R_w^{\ 2/3}\right)^2 \tag{3.2}$$

where the subscripts b and w stand for bed and wall, respectively. Equation 3.2 can be simplified to

$$\frac{R}{n^{3/2}} = \frac{R_b}{n_b^{\ 3/2}} = \frac{R_w}{n_w^{\ 3/2}} \tag{3.3}$$

Using $R = A/P$, Equation 3.3 becomes

$$\frac{A}{n^{3/2}P} = \frac{A_b}{n_b^{\ 3/2}\ P_b} = \frac{A_w}{n_w^{\ 3/2}\ P_w} \tag{3.4}$$

or

$$A_b\ (n_w^{\ 3/2}\ P_w) = A_w(n_b^{\ 3/2}\ P_b) \tag{3.5}$$

It is known that $A = A_b + A_w$, or $A_b = A - A_w$, so

$$(A - A_w)(n_w^{\ 3/2}\ P_w) = A_w\ (n_b^{\ 3/2}\ P_b)$$

$$A\ (n_w^{\ 3/2}\ P_w) - A_w\ (n_w^{\ 3/2}\ P_w) = A_w\ (n_b^{\ 3/2}\ P_b)$$

$$A\ (n_w^{\ 3/2}\ P_w) = A_w\ (n_w^{\ 3/2}\ P_w + n_b^{\ 3/2}\ P_b)$$

$$A\ \frac{n_w^{\ 3/2}\ P_w}{A_w} = n_w^{\ 3/2}\ P_w + n_b^{\ 3/2}\ P_b \tag{3.6}$$

Equations 3.4 indicate that

$$\left(\frac{n_w^{\ 3/2}\ P_w}{A_w}\right) A = n^{3/2}\ P \tag{3.7}$$

Substituting Equation 3.7 into Equation 3.6

$$n^{3/2}\ P = n_w^{\ 3/2}\ P_w + n_b^{\ 3/2}\ P_b \tag{3.8}$$

In Equation 3.8, n and P are the overall Manning's n and wetted perimeter of the flume, that represent the combined effect of both the walls and the bed. For a flume width W and flow depth D,

$$P = W + 2D \tag{3.9}$$

$$n = \frac{1.49}{V} \left(\frac{WD}{W + 2D} \right)^{2/3} S^{1/2} \tag{3.10}$$

and,

$$P_w = 2D \tag{3.11}$$

$$P_b = W \tag{3.12}$$

Knowing that the flume is built out of smooth painted metal and Plexiglas, (Chow, 1959, pp. 110-111)

$$n_w = 0.012 \tag{3.13}$$

The flume width is 8.0 ft. Substituting these values and using Equation 3.11 and 3.12, in Equation 3.8

$$n^{3/2}\ P = (0.012)^{3/2}\ (2D) + n_b{}^{3/2}\ (8)$$

and solving for n_b

$$n_b = \left[\frac{n^{3/2}\ P - (0.012)^{3/2}\ (2D)}{8} \right]^{2/3} \tag{3.14}$$

where n and P are determined by Equations 3.9 and 3.10, or

$$P = 8 + 2D \tag{3.15}$$

$$n = \frac{1.49}{V} \left(\frac{8D}{8 + 2D} \right)^{2/3} S^{1/2} \tag{3.16}$$

Equation 3.14 was used for calculating Manning's roughness factors, n_b, for the riprap surface.

To calculate the Shields coefficient, Equation 2.3 (chapter 2) was used. The values of Shields coefficient were plotted against the washed area. The lines fitted to the data were extended to the point of zero washed area, at which the value of Shields coefficient would be the critical value causing incipient motion of the riprap particles. The results are shown in Section 3.3.

An alternative method to the determination of the critical Shields coefficient was also used. As explained in the experimental procedure (Section 2.5), after each riprap failure the flume slope was reduced and the appropriate discharge was routed to make sure stable conditions (no riprap washout) occurred. Assuming those conditons were incipient motion conditions, the Shields coefficient for the bed can be determined. Again the wall effect has to be eliminated. Similar to the Manning equation analysis, the Darcy-Weisbach equation is assumed to apply to the wall, bed, and the entire channel, i.e.,

$$\frac{V^2}{8} = \frac{g\ S\ R}{f} = \frac{g\ S\ R_w}{f_w} = \frac{g\ S\ R_b}{f_b} \qquad (3.17a)$$

or

$$\frac{R}{f} = \frac{R_w}{f_w} = \frac{R_b}{f_b} \qquad (3.17b)$$

where f is the Darcy-Weisbach friction factor and other terms as defined before. Using $R = A/P$ and $A = A_w + A_b$ in Eq. 3.17b, a procedure similar to the development of Equation 3.6 results in

$$Pf = P_w\ f_w + P_b\ f_b \qquad (3.18)$$

In this case $P = 8 + 2D$; $P_w = 2D$; and $P_b = 8$. Therefore, Equation 3.18 becomes

$$f_b = f + \frac{D}{4}(f - f_w) \tag{3.19}$$

To find f_w Reynolds number for each section is used as

$$\mathbf{R} = \frac{4\,R\,V}{\nu}\ ; \quad \mathbf{R}_w = \frac{4\,R_w\,V}{\nu} \tag{3.20}$$

Combining Equations 3.20 and 3.17b yields

$$\frac{\mathbf{R}_w}{f_w} = \frac{\mathbf{R}}{f} \tag{3.21}$$

Equation 3.21 can be solved by any of the existing methods for pipe friction, such as the Moody diagram, or the one given by ASCE (Reference No. 8, p. 153). The value of f_w as found from Equation 3.21 is used in Equation 3.19 to find f_b, and R_b is calculated from Equation 3.17a. The critical Shields coefficient can be determined from Equation 2.2.

Other equations used for some specific purposes in the data analysis will be explained as they appear. Tables 3.1, 3.2, and 3.3 show the results of calculations for the three riprap sizes. These results will be used in the subsequent analyses.

3.2 Representative Velocity Distributions at the Incipient Motion Conditions

After each riprap failure the slope was reduced and a prolonged run performed to find the stable conditions for the specific riprap size and discharge under study (Section 2.5). These conditions are referred to hereafter as the incipient motion conditions. Representative velocity distributions for these conditions have been plotted and presented in Figures 3.1 through 3.9, in which x refers to distance along the test section and y refers to distance across the section.

3.3 Determination of Incipient Motion Conditions

The procedure for determining the incipient motion conditions using the washed areas has been explained in Section 3.1. Figures 3.10-3.13

Table 3.1. Calculations for the 3/4-Inch Riprap

Run No.	Orifice discharge Q cfs	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number $\mathbb{F}^{(1)}$	Manning's roughness factor $n_b^{(2)}$	Shields coefficient $C^{(3)}$	Area washed ft^2	Boundary Reynolds number $R_*^{(4)}$
1	25	0.00312	3.23	0.964	0.58	0.024	0.029	-	1945
2		0.00470	3.62	0.870	0.68	0.025	0.040	1.59	2268
3		0.00470	3.62	0.853	0.69	0.024	0.039	0.13	2246
4		0.00557	3.81	0.823	0.74	0.024	0.044	0.66	2401
5		0.00389	3.70	0.859	0.70	0.021	0.032	0.45	2050
6	50	0.00133	3.37	1.820	0.44	0.021	0.023	-	1745
7		0.00215	3.71	1.624	0.51	0.023	0.034	-	2096
8		0.00307	4.34	1.431	0.64	0.022	0.043	38.0	2351
9		0.00260	4.18	1.497	0.60	0.022	0.038	25.0	2213
10		0.00215	3.88	1.608	0.54	0.022	0.034	4.0	2085
11	75	0.00094	3.69	2.680	0.40	0.020	0.024	-	1780
12		0.00152	4.15	2.395	0.47	0.022	0.035	-	2140
13		0.00217	4.47	2.129	0.54	0.023	0.045	40.0	2411
14		0.00183	4.31	2.188	0.51	0.022	0.039	12.0	2244
15		0.00152	4.10	2.273	0.48	0.021	0.034	1.42	2085
16	100	0.00095	4.18	3.016	0.42	0.018	0.028	-	1898
17		0.00143	4.35	2.802	0.46	0.022	0.039	9.7	2245
18		0.00118	4.26	2.830	0.45	0.020	0.032	5.0	2049
19		0.00095	4.07	2.952	0.42	0.019	0.027	-	1878

(1) Equation 3.1

(2) Equation 3.14

(3) Equation 2.3

(4) $$R_* = \frac{V_* d_{50}}{\nu} = \frac{\sqrt{gDS}\ d_{50}}{1\mathrm{x}10^{-5}}$$

Table 3.2. Calculations for the 2-Inch Riprap

Run No.	Orifice discharge Q cfs	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number $F^{(1)}$	Manning's roughness factor $n_b^{(2)}$	Shields coefficient $C^{(3)}$	Area washed ft^2	Boundary Reynolds number $R_*^{(4)}$
1	25	0.00852	3.62	0.825	0.70	0.032	0.027	-	7,414
2		0.01378	4.34	0.687	0.92	0.031	0.037	-	8,604
3		0.01667	4.62	0.653	1.01	0.031	0.042	4.0	9,226
4		0.01973	5.11	0.629	1.14	0.029	0.048	-	9,851
5	50	0.00761	4.78	1.218	0.76	0.029	0.036	-	8,513
6		0.01089	5.24	1.110	0.88	0.030	0.047	-	9,722
7		0.01451	5.92	1.032	1.03	0.030	0.058	89.0	10,821
8		0.01266	6.01	1.051	1.03	0.027	0.052	40.0	10,200
9		0.01089	5.35	1.151	0.88	0.030	0.049	2.5	9,900
10	75	0.00537	5.39	1.868	0.69	0.028	0.039	-	8,857
11		0.00769	5.38	1.716	0.72	0.033	0.051	-	10,158
12		0.01025	5.92	1.509	0.85	0.032	0.060	17.0	10,998
13		0.00894	5.64	1.604	0.78	0.032	0.056	6.0	10,589
14		0.00769	5.39	1.700	0.73	0.032	0.051	-	10,111
15	100	0.00420	5.39	2.325	0.62	0.028	0.038	-	8,738
16		0.00601	5.32	2.111	0.65	0.033	0.049	-	9,960
17		0.00801	6.03	2.010	0.75	0.033	0.063	33.0	11,220
18		0.00699	5.86	2.012	0.73	0.031	0.055	4.0	10,487
19		0.00601	5.68	2.062	0.70	0.030	0.048	-	9,844

(1) Equation 3.1
(2) Equation 3.14
(3) Equation 2.3

(4) $$R_* = \frac{V_* d_{50}}{} = \frac{\sqrt{gDS}\, d_{50}}{1\times10^{-5}}$$

Table 3.3. Calculations for the 3-Inch Riprap

Run No.	Orifice discharge Q cfs	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number $F^{(1)}$	Manning's roughness factor $n_b^{(2)}$	Shields coefficient $C^{(3)}$	Area washed ft^2	Boundary Reynolds number $R_*^{(4)}$
1	25	0.02000	4.51	0.655	0.98	0.034	0.032	-	16,237
2	50	0.01544	5.55	1.064	0.95	0.034	0.040	-	18,183
3		0.02000	6.09	1.026	1.06	0.034	0.050	-	20,322
4	75	0.01500	6.60	1.348	1.00	0.032	0.049	4.0	20,172
5		0.01719	6.55	1.363	0.99	0.035	0.057	15.0	21,715
6		0.01500	6.72	1.387	1.01	0.032	0.050	3.5	20,464
7		0.01291	6.41	1.401	0.95	0.031	0.044	-	19,079
8	100	0.01009	6.14	1.831	0.80	0.034	0.045	-	19,282
9		0.01343	6.54	1.703	0.88	0.036	0.055	10.0	21,454
10		0.01172	6.37	1.825	0.83	0.036	0.052	0.2	20,747

(1) Equation 3.1

(2) Equation 3.14

(3) Equation 2.3

(4) $$R_* = \frac{V_* d_{50}}{} = \frac{\sqrt{gDS}\ d_{50}}{1\mathrm{x}10^{-5}}$$

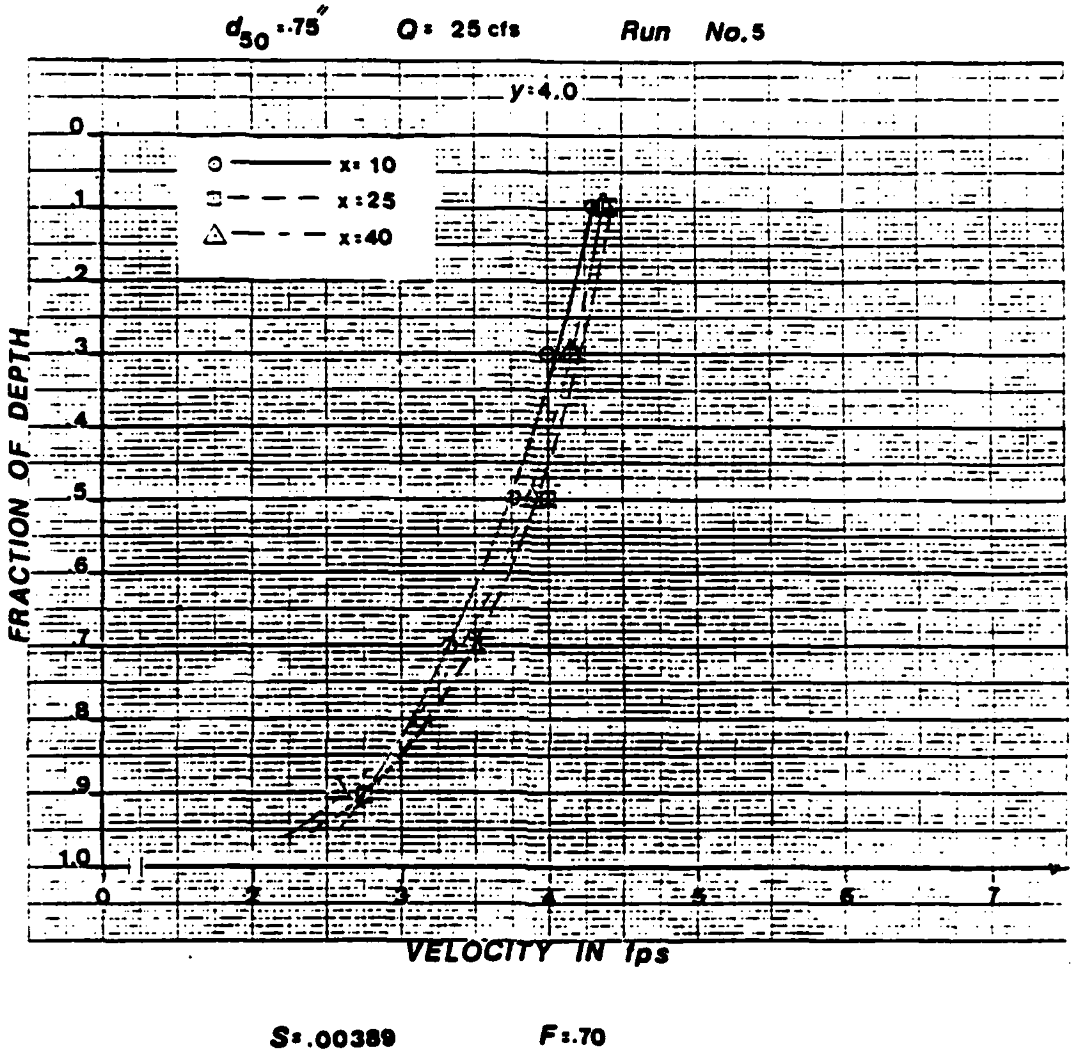

Figure 3.1. Velocity Profile for 3/4" Riprap, Run No. 5

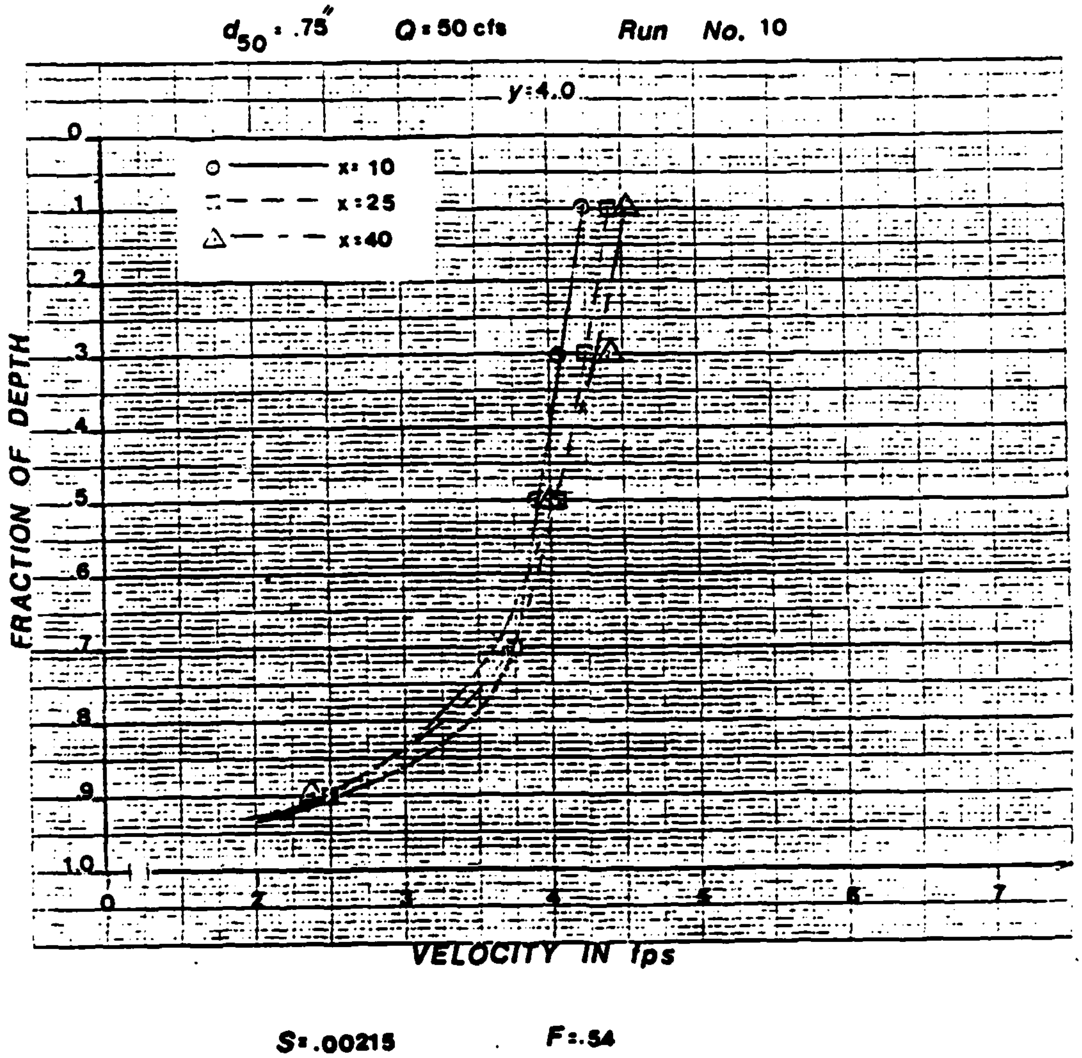

Figure 3.2. Velocity Profile for 3/4" Riprap, Run No. 10

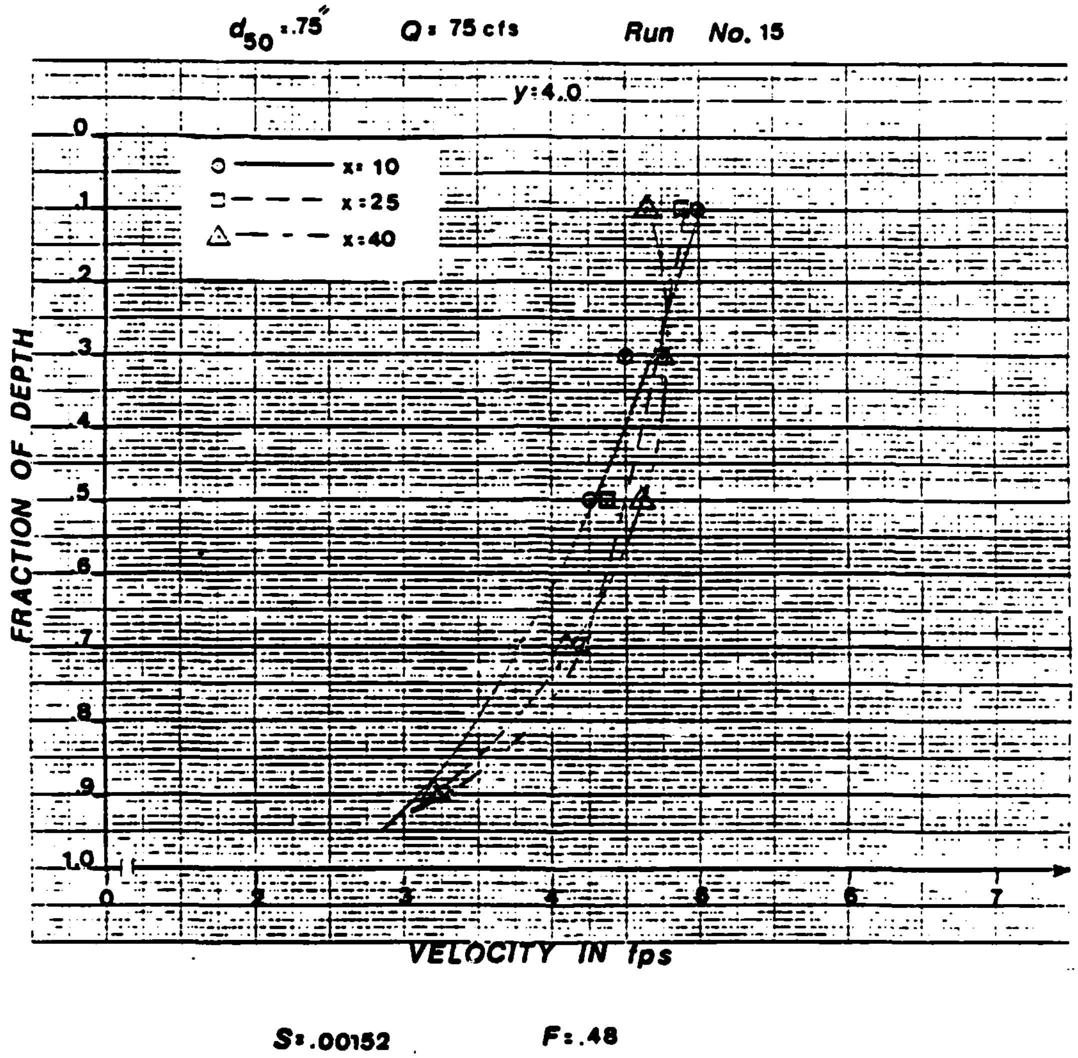

Figure 3.3. Velocity Profile for 3/4" Riprap, Run No. 15

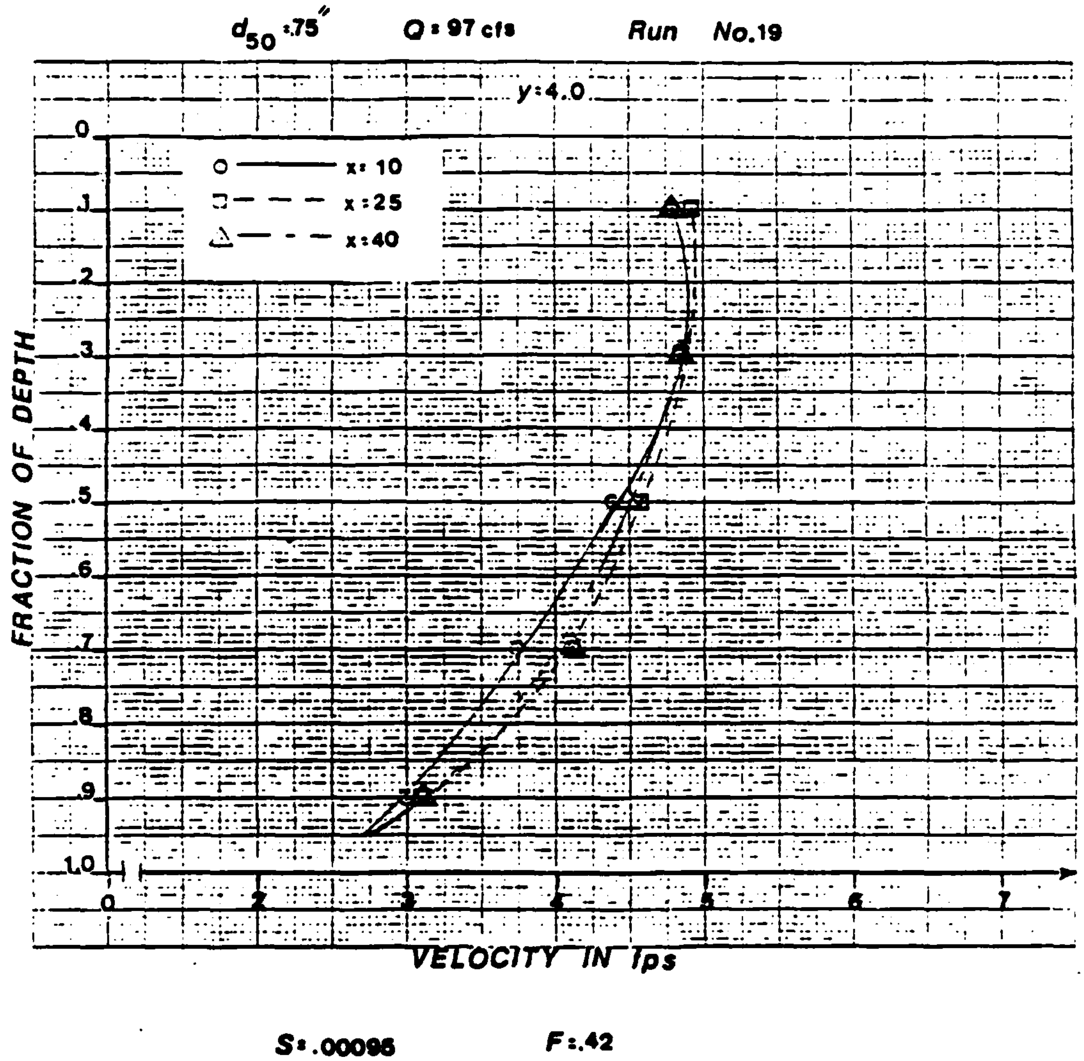

Figure 3.4. Velocity Profile for 3/4" Riprap, Run No. 19

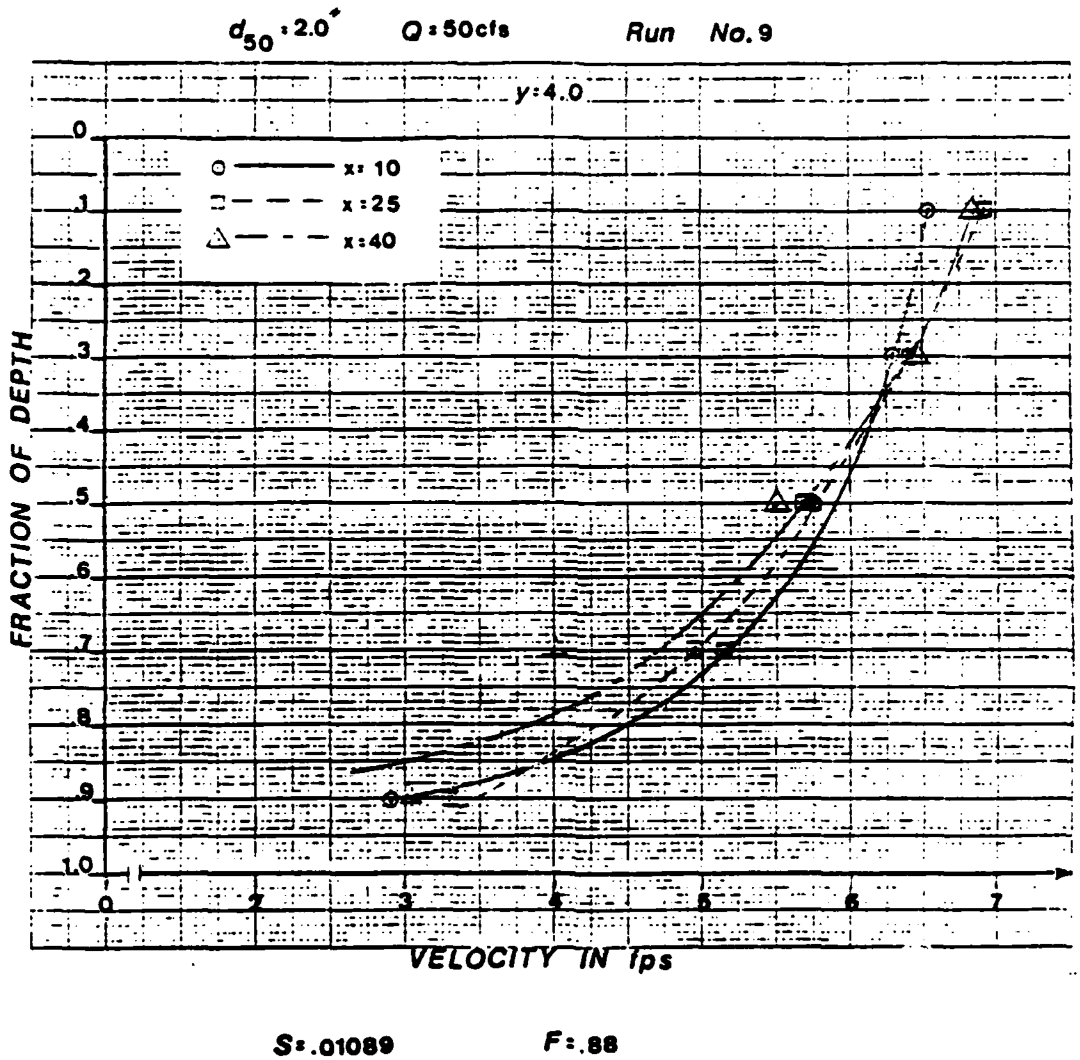

Figure 3.5. Velocity Profile for 2" Riprap, Run No. 9

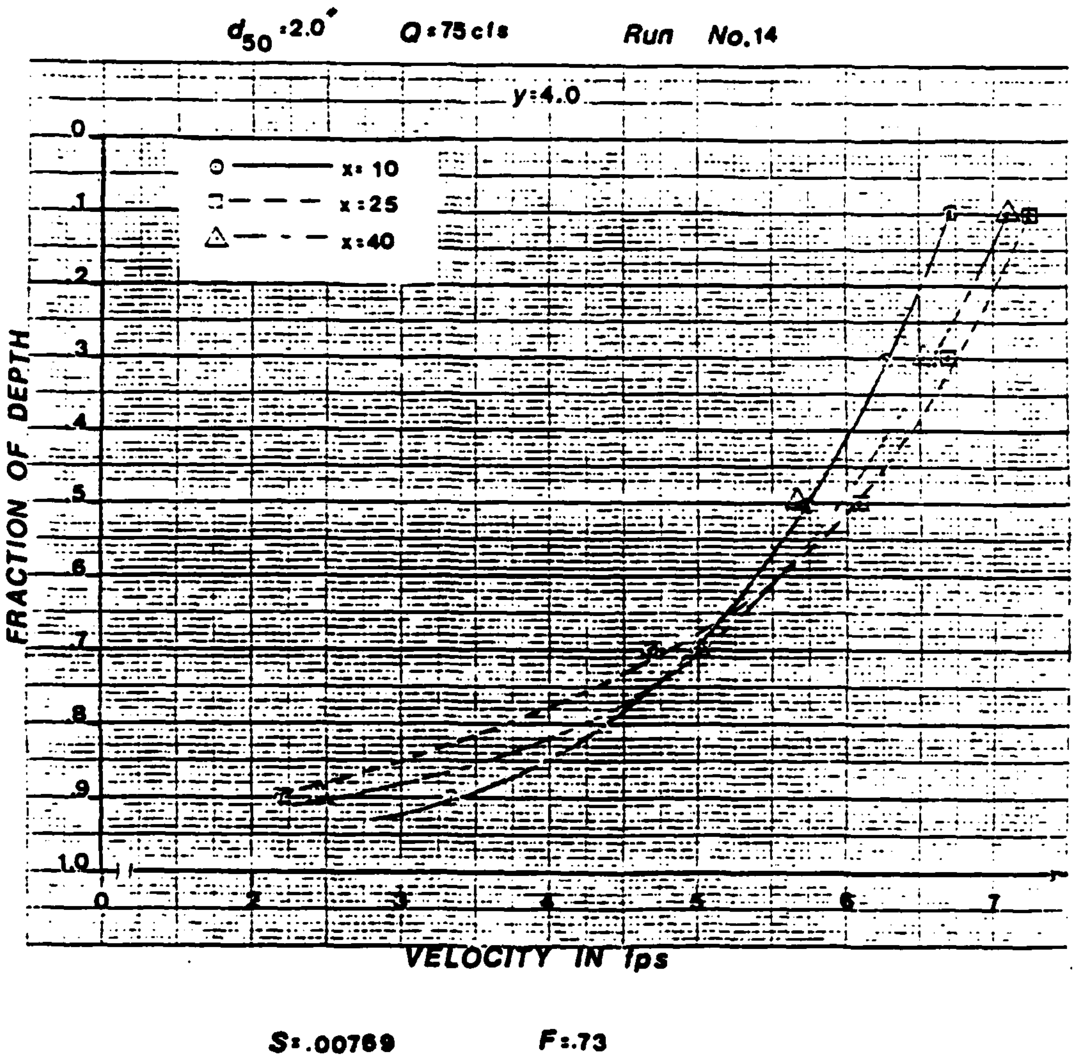

Figure 3.6. Velocity Profile for 2" Riprap, Run No. 14

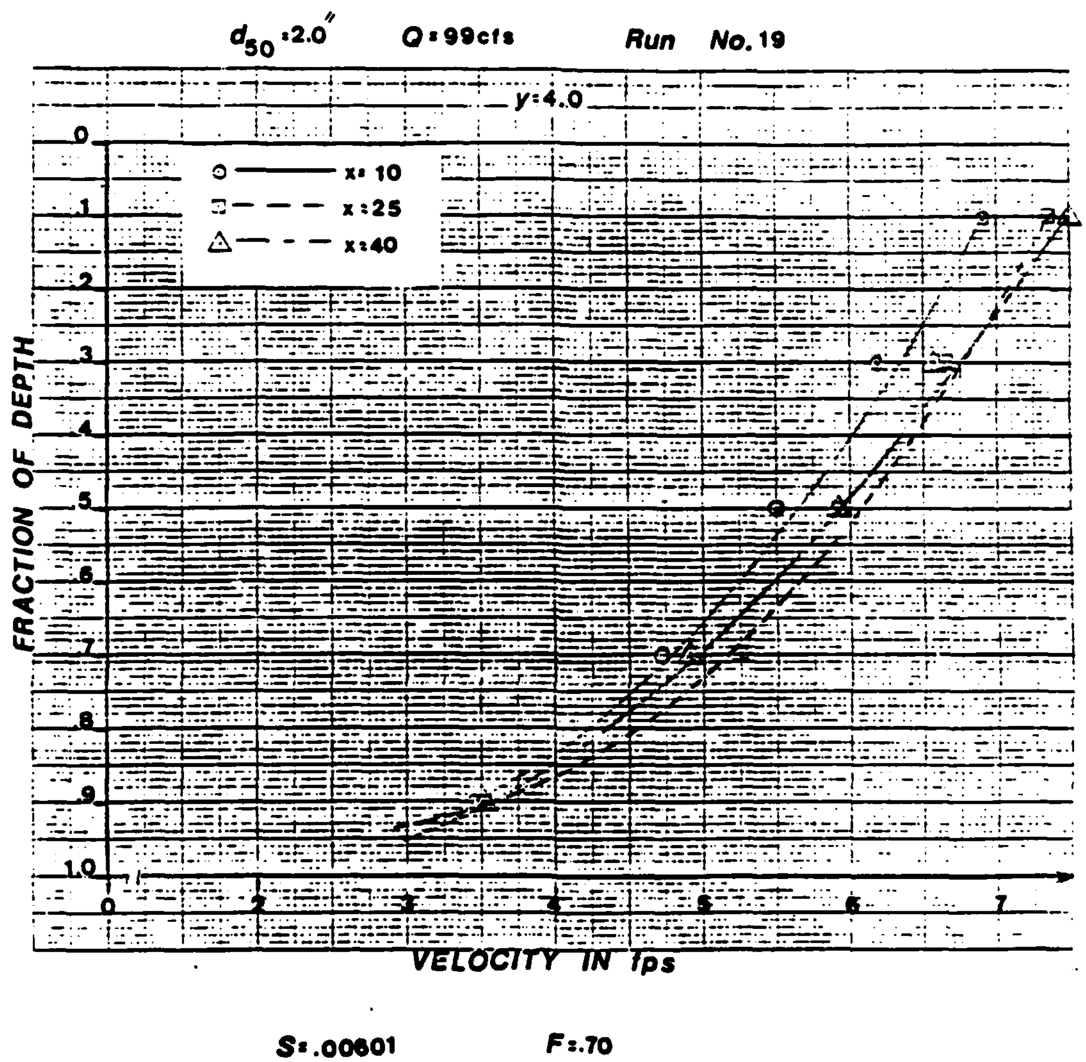

Figure 3.7. Velocity Profile for 2" Riprap, Run No. 19

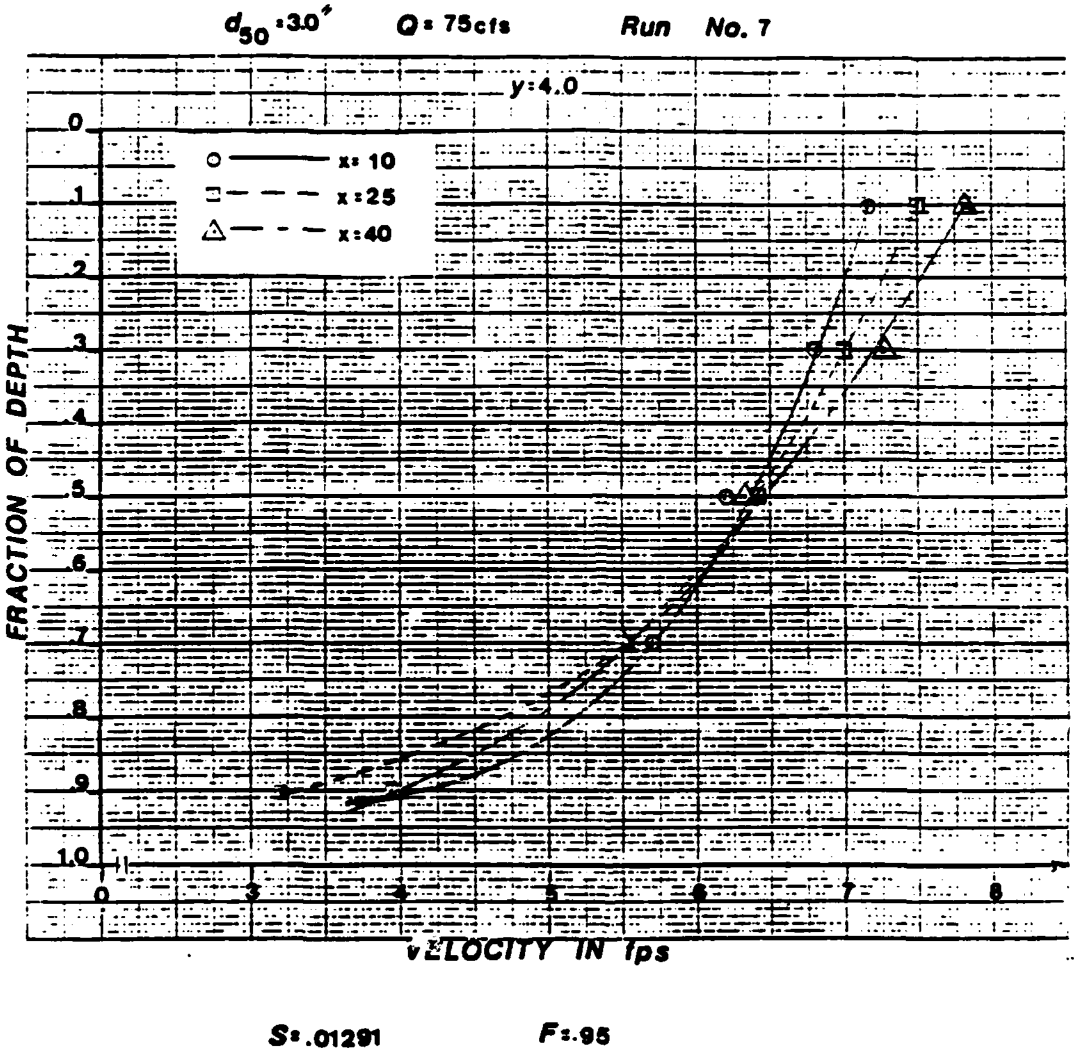

Figure 3.8. Velocity Profile for 3" Riprap, Run No. 7

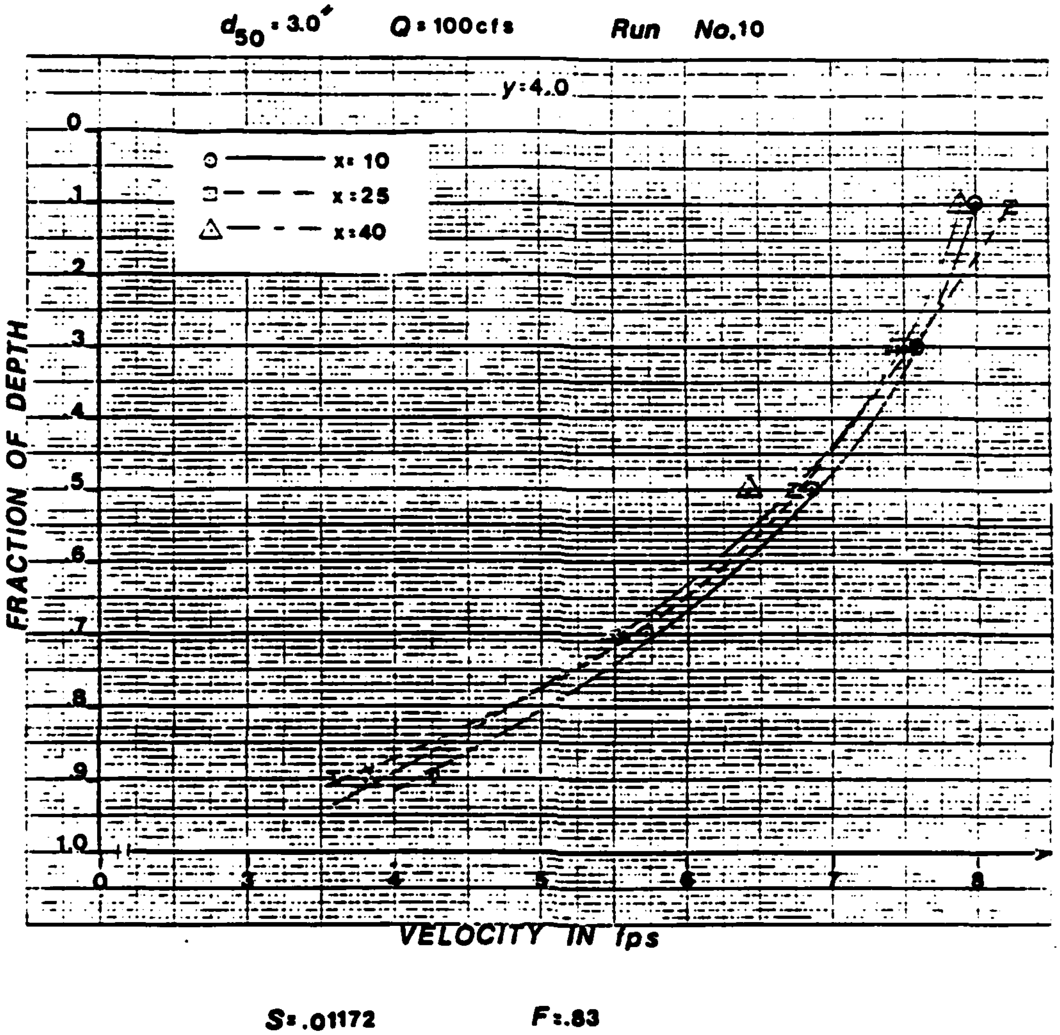

Figure 3.9. Velocity Profile for 3" Riprap, Run No. 10

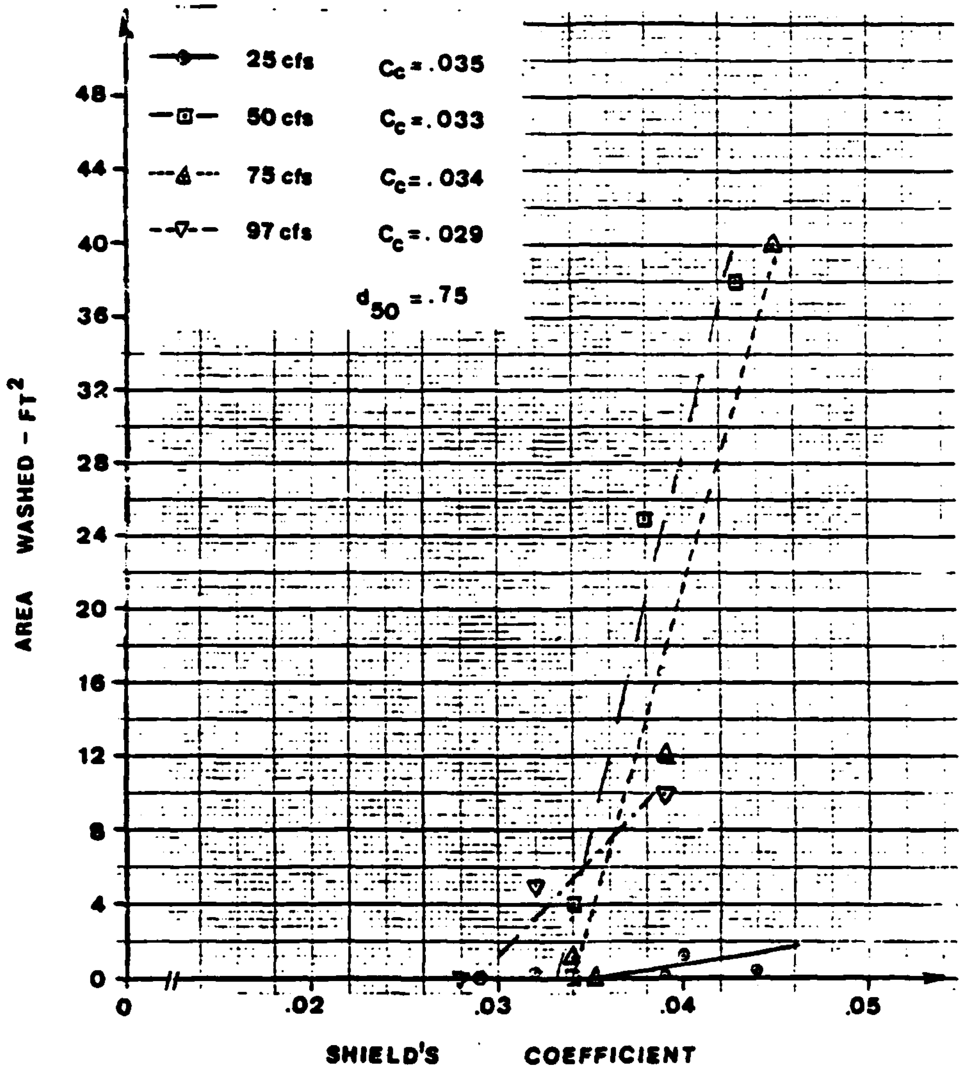

Figure 3.10. Determination of the Critical Shields Coefficient from Washed Areas for 3/4-inch Riprap

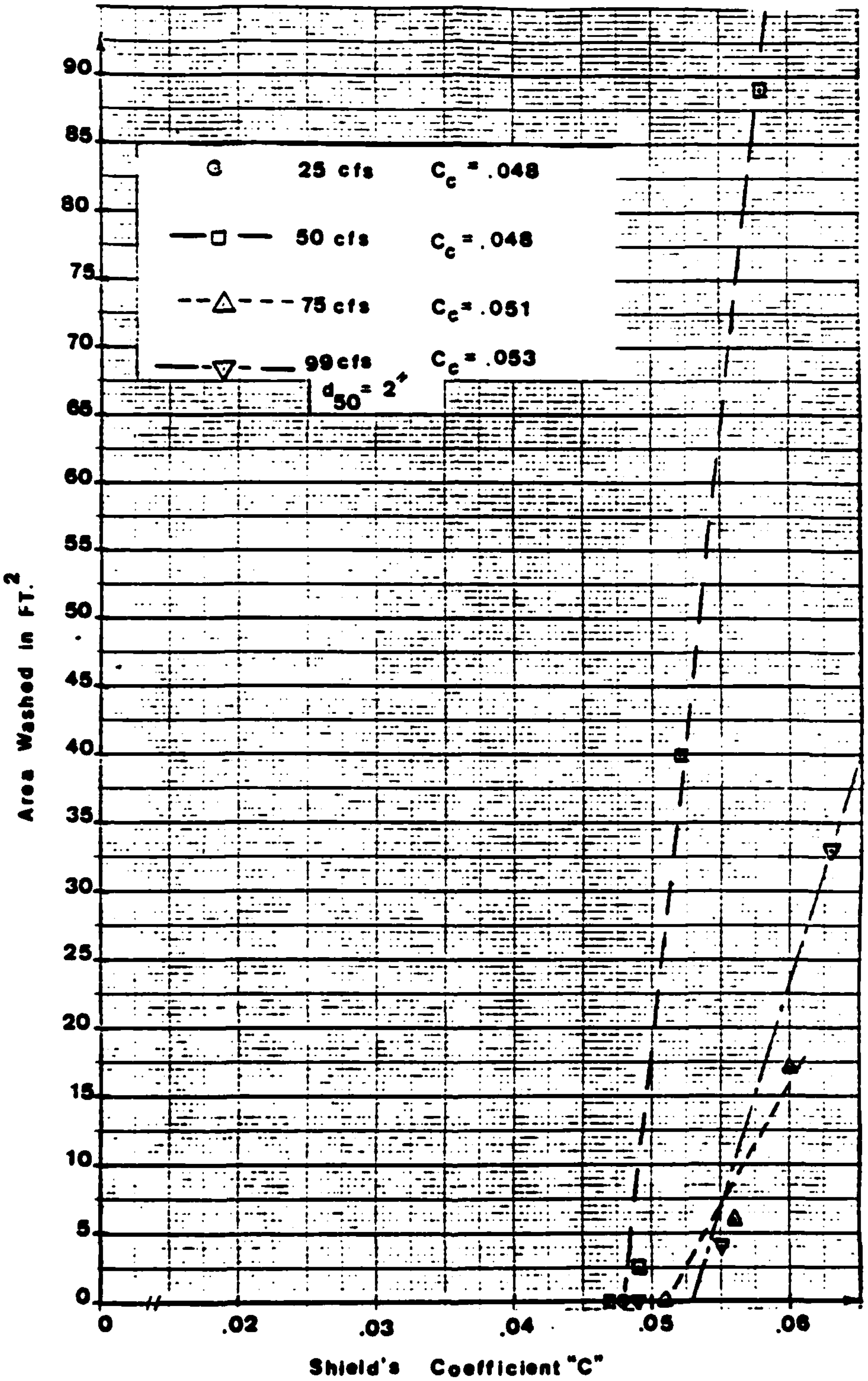

Figure 3.11. Determination of the Critical Shield's Coefficient from Washed Areas for 2-inch Riprap

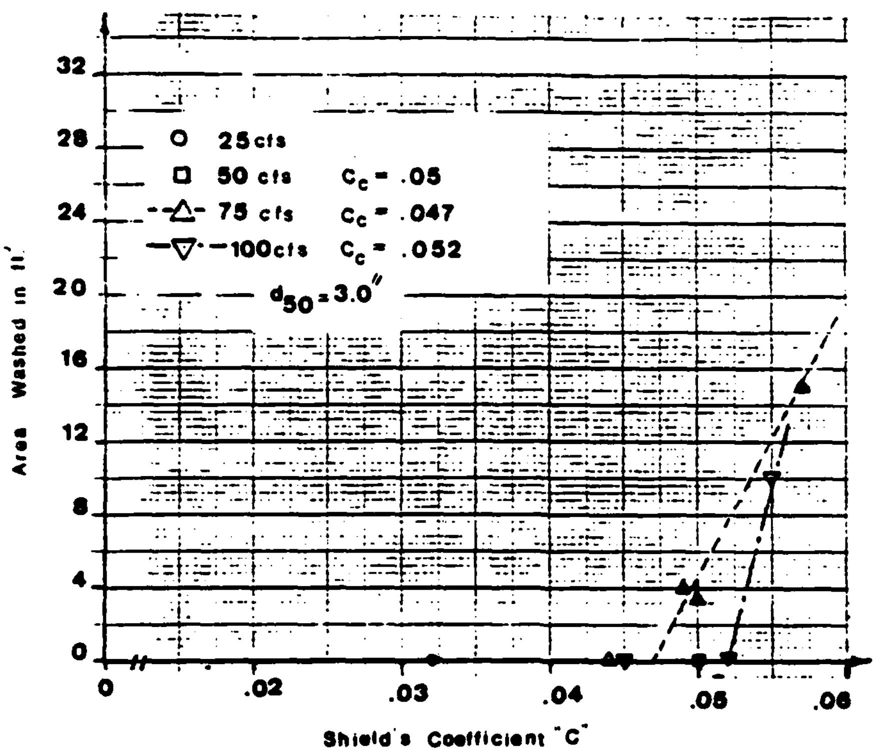

Figure 3.12. Determination of the Critical Shields Coefficient from Washed Areas for the 3-inch Riprap

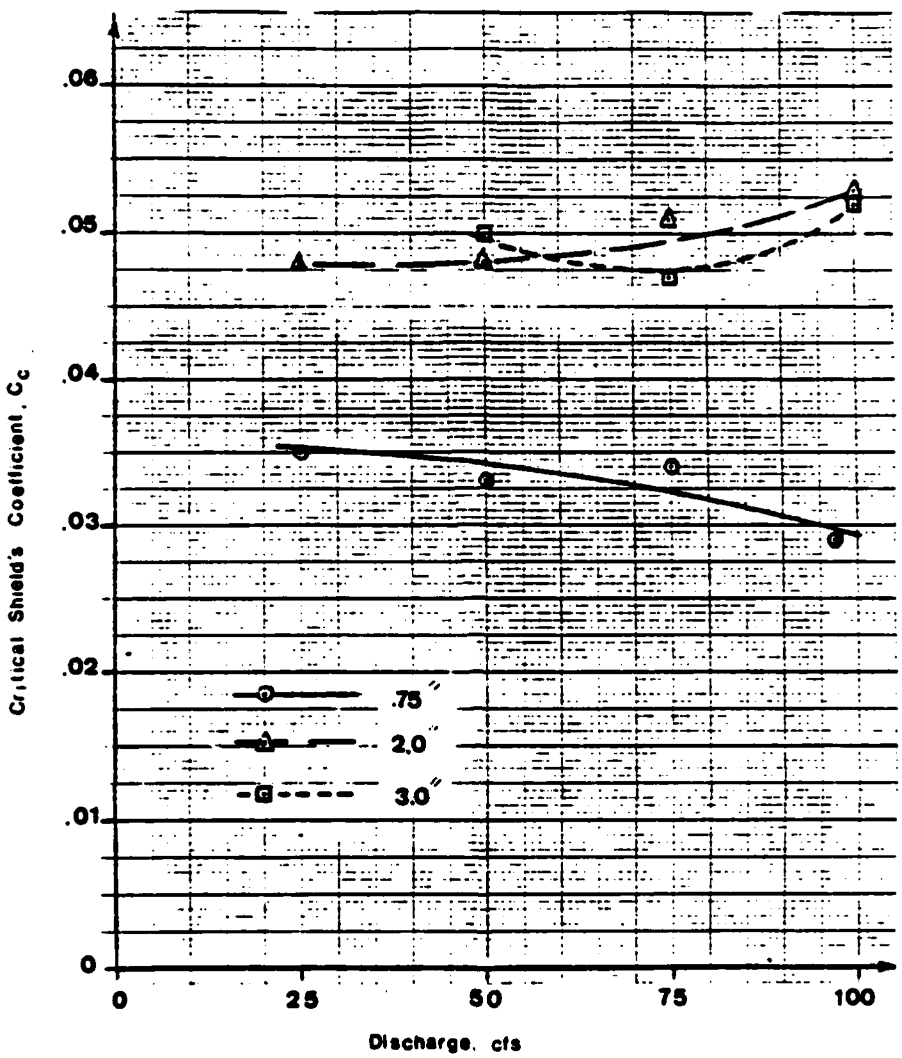

Figure 3.13. Variation of the Critical Shield's Coefficient with Discharge

show the results of the analysis. Variation of the critical Shields coefficient, C_c, with discharge does not seem to follow any specific trend. Discussion of the results are presented in Chapter 4. Further analysis of the critical Shields coefficient is presented in the remainder of this chapter.

3.4 Maximum Stable Slopes at the Incipient Motion Conditions

Tables 3.1, 3.2, and 3.3 show the flume slopes for each run. The maximum slopes at which riprap was stable are called the maximum stable slopes and are plotted in Figure 3.14. The trends of variation are as expected.

3.5 Comparisons with Shields Diagram

Values of the critical Shields coefficient as determined from Figures 3.10 to 3.12 (Section 3.3) have been plotted in Figure 3.15. On the same figure is the original Shields curve and the modification of the curve by J. Gessler (1971). Values of the boundary Reynolds number for Figure 3.15 were obtained directly or by interpolation from Tables 3.1 to 3.3. It should be noted that Shields diagram has been developed for the movement of bed material in alluvial channels, and the critical value of Shields coefficient is an average value at which no more than 50 percent of the particles move. However, in riprap design, the incipient motion criteria are different. Therefore, the critical value of Shields coefficient for use in design of stable riprap should be considerably less than the value of 0.06 suggested by Shields. Further analysis of the appropriate Shields coefficient is done in the next section and in Chapter 4.

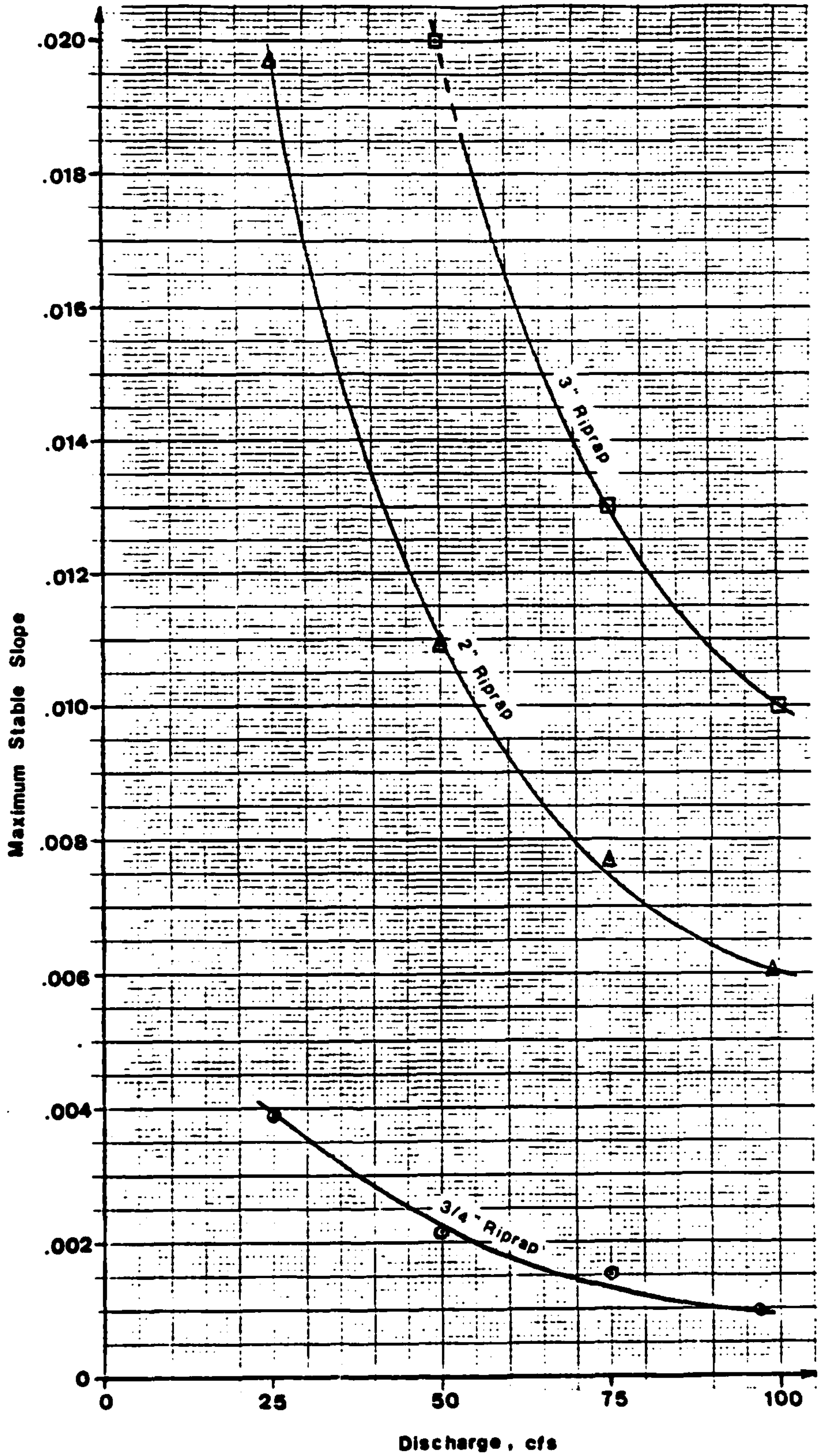

Figure 3.14. Variation of the Maximum Stable Slope with Discharge for the Three Sizes

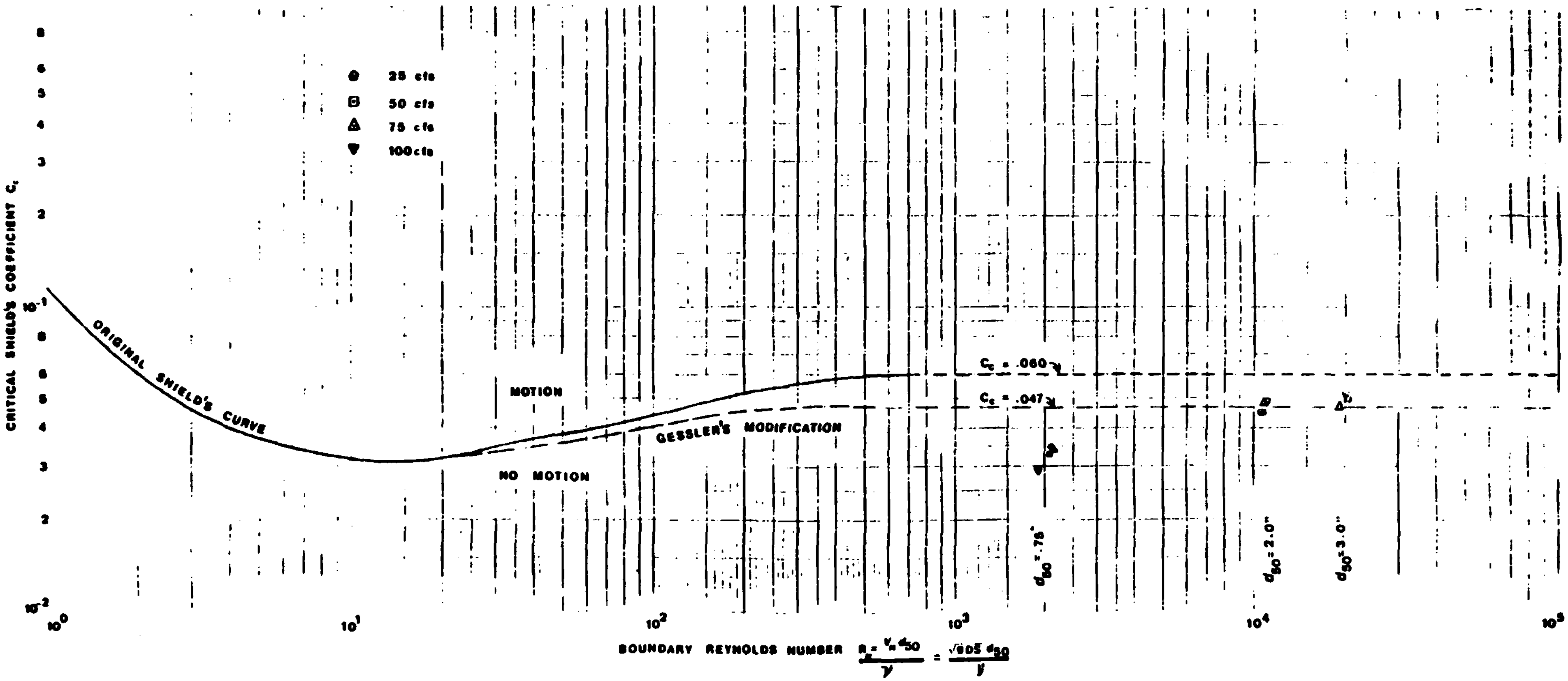

Figure 3.15. The Shields Diagram

3.6 Determination of Bed Critical Shields Coefficient

As mentioned in Section 3.1, those runs under maximum stable slopes can be considered "incipient motion" runs, from which values of the bed critical Shields coefficient can be determined. The summary of the incipient motion runs are shown in Table 3.4. The table also contains calculations of f_b by Eq. 3.19 and C_{cb} from Equation 2.2. Values of Froude number for each run are also shown in Table 3.4.

The last column in Table 3.4 contains the values of C_c determined in Section 3.3 by the washed-area analysis. These values are higher than the values of C_{cb} calculated in Table 3.4, as expected. There are two reasons for this:

1. The effect of the smooth flume walls have not been eliminated in the area analysis, hence C_c turns out to be larger.
2. The slopes of the "incipient motion" runs have been selected from Tables 3.1-3.3 which are based on discrete values of slope. The true incipient motion slope for every discharge may lie in between two of the values calculated in Tables 3.1-3.3, hence C_{cb} turns out to be smaller. This point is discussed in Chapter 4.

The column labeled $\frac{d_{50}}{D}$ in Table 3.4 will be used in Section 3.7.

3.7 Froude Number Analysis of WES

A different method of analysis has been used by WES to arrive at the critical Shields coefficient, which is presented here. From Eq. 2.3 for the incipient motion condition,

$$S = C_{cw}(s-1) \frac{d_{50}}{D} \tag{3.22}$$

Table 3.4. Calculation of the Bed Critical Shields Coefficient

Median size in	Run No.	Slope	Average velocity fps	Average Depth ft	f	f_w ft	f_b	R_b	C_{cb}	F	$\frac{d_{50}}{D}$	C_c
0.75	5	0.00389	3.70	0.859	0.052	0.014	0.060	0.817	0.031	0.70	0.073	0.035
	10	0.00215	3.88	1.608	0.042	0.013	0.054	1.466	0.031	0.54	0.039	0.033
	15	0.00152	4.10	2.273	0.034	0.012	0.046	1.980	0.029	0.48	0.028	0.034
	19	0.00095	4.07	2.952	0.025	0.011	0.035	2.407	0.022	0.42	0.021	0.029
1.87	3	0.01667	4.62	0.653	0.113	0.017	0.129	0.639	0.041	1.01	0.240	0.048
	9	0.01089	5.35	1.151	0.088	0.014	0.109	1.109	0.047	0.88	0.136	0.048
	14	0.00769	5.39	1.700	0.081	0.014	0.110	1.616	0.048	0.73	0.092	0.051
	19	0.00601	5.68	2.062	0.065	0.013	0.092	1.923	0.045	0.70	0.076	0.053
3.00	7	0.01291	6.41	1.401	0.084	0.014	0.109	1.343	0.042	0.95	0.179	0.047
	10	0.01172	6.37	1.825	0.093	0.013	0.130	1.744	0.050	0.83	0.137	0.052

where C_{cw} denotes values calculated by WES analysis. Subsitituting for S in Manning's equation

$$V = \frac{1.49}{n} D^{2/3} [C_{cw}(s-1) \frac{d_{50}}{D}]^{1/2} \tag{3.23}$$

Assuming an equation of the type

$$n = K\, d_{50}^{1/6} \tag{3.24}$$

and substituting it in Eq. 2.3

$$V = \frac{(1.49)(s-1)^{1/2}}{K\, d_{50}^{1/6}} C_{cw}^{1/2} (\frac{d_{50}}{D})^{1/2} D^{2/3}$$

or

$$\frac{V}{D^{1/2}} = \frac{(1.49)(s-1)^{1/2}}{K} C_{cw}^{1/2} (\frac{d_{50}}{D})^{1/3} \tag{3.25}$$

Dividing both sides of Eq. 3.25 by $\sqrt{g}$

$$\frac{V}{\sqrt{gD}} = \frac{(1.49)(s-1)^{1/2}}{K\sqrt{g}} C_{cw}^{1/2} (\frac{d_{50}}{D})^{1/3} = F \tag{3.26}$$

Equation 3.26 can be solved for $\frac{d_{50}}{D}$

$$\frac{d_{50}}{D} = \frac{K^3 g^{3/2}}{(1.49)^3 (s-1)^{3/2} C_{cw}^{3/2}} F^3 \tag{3.27}$$

Subsituting the values of $g = 32.2$ and $s = 2.65$ in Eq. 3.27

$$\frac{d_{50}}{D} = \frac{26.06\, K^3}{C_{cw}^{3/2}} F^3 \tag{3.28}$$

Table 3.4 shows values of $\frac{d_{50}}{D}$ and F for the incipient motion runs. The best-fit equation to $\frac{d_{50}}{D}$ and F^3 is

$$\frac{d_{50}}{D} = 0.222\ F^3 \tag{3.29}$$

which is the equation of the line shown in Fig. 3.16. It can be concluded from Eqs. 3.28 and 3.29, that

$$\frac{26.06\ K^3}{C_{cw}^{\ 3/2}} = 0.222 \tag{3.30}$$

Values of K can be determined from the Manning's n (Tables 3.1-3.3). The calculations are shown in Table 3.5, in which the values of Manning's n are representative averages obtained for each riprap size from Tables 3.1-3.3. Table 3.5 shows that K (Eq. 3.24) shows a trend of variation with d_{50}, which indicates that the power 1/6 as shown in Eq. 3.24 needs to be modified. However, taking an average value of 0.040 for K from the three sizes produces an equivalent value of 0.038 for the critical Shields coefficient form Eq. 3.30. Comparison of the values of the critical Shields coefficient listed in Table 3.5 to those listed in Table 3.4 shows good agreement between the two tables.

Table 3.5 Calculations of the Critical Shields Coefficient-WES Analysis

d_{50} in	d_{50} ft	n_b	K	C_{cw} (1)
0.75	0.063	0.022	0.035	0.029
1.87	0.156	0.031	0.042	0.042
3.00	0.250	0.034	0.043	0.044
Average K = 0.040 for which C_{cw} = 0.038				

(1) Eq. 3.30

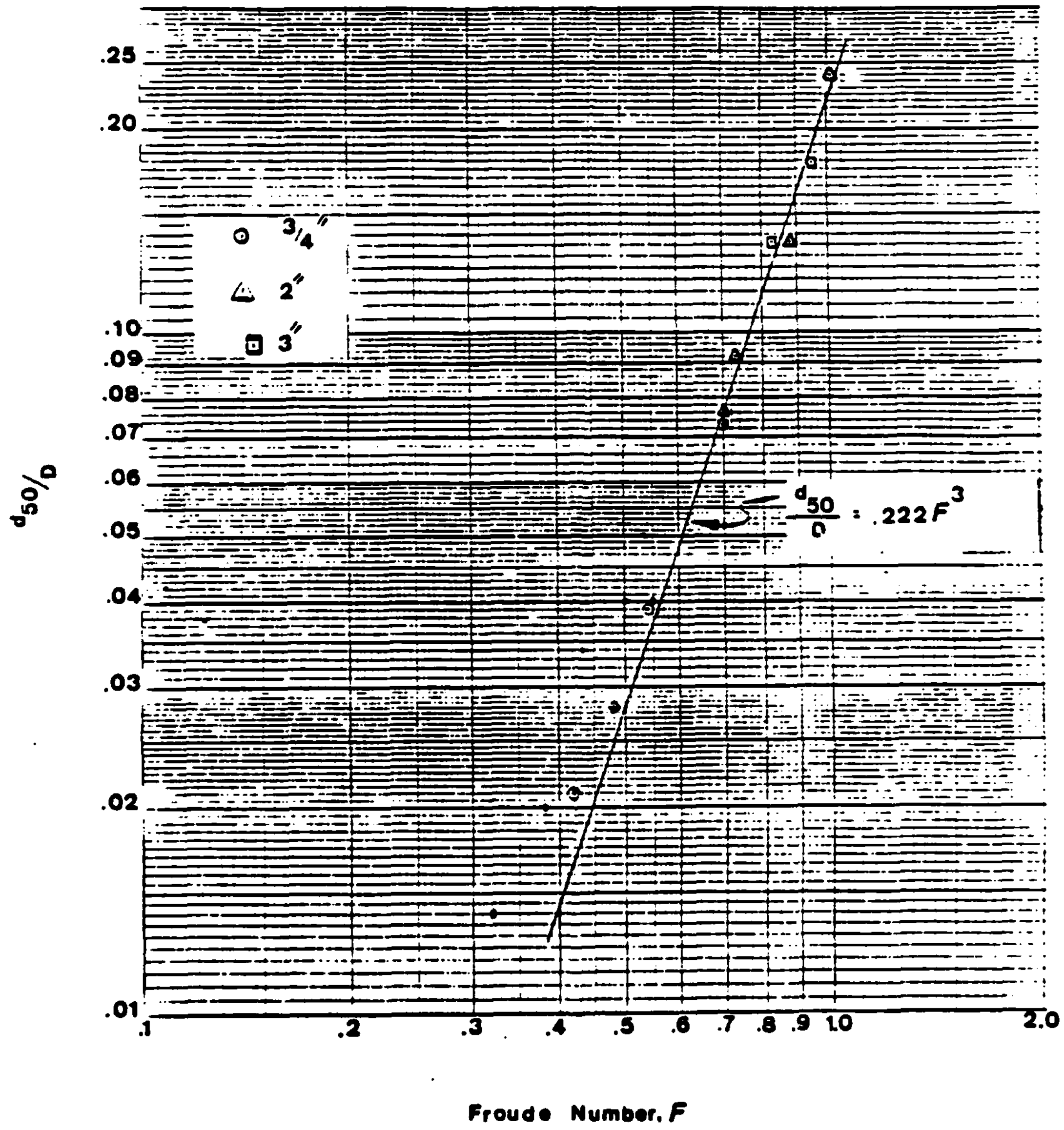

Figure 3.16. $\frac{d_{50}}{D}$ vs. Froude Number

CHAPTER 4

DISCUSSION OF THE RESULTS

Major effort in analyzing the data has been concentrated on determining values of the critical Shields coefficient using different methods of analysis. The results were shown in Sections 3.3, 3.5, 3.6, and 3.7. The overall results show that the values of the critical Shields coefficient are always below 0.06 which was suggested by Shields. It was already mentioned in Section 3.5, that for riprap design, a value less than 0.06 must be used to ensure that no riprap particle is dislodged and moved by the flow.

Of the three methods used in Sections 3.3, 3.6 and 3.7, the method of Section 3.6 eliminates the effects of the smooth flume walls on the flow conditions, and results in values of C_c determined solely for the riprapped bed. However, its results do not show considerable differences for the values of the critical Shields' coefficient.

This study has shown an overall variation of the critical shields coefficient from 0.022 to 0.053 using the different methods of analysis. Other studies such as the one by Abdus-Samad (1) also indicate that the variation of Shields coefficient can be over a wide range. However, conservative values of the coefficient should be used for design purposes since no movement of any riprap particle is desired. In order to avoid overdesign criteria other than the Shields coefficient may be employed for the design of stable riprap. Of the various factors considered in this report, the Froude number as presented in section 3.7 offers the best and most significant factor. The following design procedure is therefore based on the analysis of section 3.7, which is expected to result in reasonable and acceptable values of the Shields coefficient.

4.1 Design of Stable Riprap

Based on the data as presented in Chapter 3 of this report, the procedure for the design of stable ripraps can be outlined in the following steps.

Step 1. Assume a reasonable size of riprap with a desired gradation. From this information Manning's roughness factor can be estimated for the riprap surface.

Step 2. Using Manning's equation (or any other open-channel equation) estimate the flow velocity and depth.

Step 3. Calculate the Froude number and use Figure 3.16 to find the corresponding value of d_{50}/depth, and hence the value of d_{50}. If the result turns out much different from the assumed size of Step 1, adjust the calculations to find a new size. Normally, no more than one iteration is necessary.

Step 4. Multiply the value of d_{50} by a factor of safety of 1.5 to 2. Figure 3.16 has been developed based on the information presented in this report and contains no factor of safety. The use of such a factor is strongly recommended for design of stable riprap.

The choice of the safety factor is somewhat arbitrary depending on the purpose for which the riprap is to be used. If the protection is crucial and the failure of the riprap may result in large losses or disasters, the safety factor may be increased to 2.5 or possibly 3. For cases when some degree of failure of the riprap surface may be allowed and provisions for subsequent repair of the riprap surface exist, the safety factor may be reduced to 1.5 or less.

It should be noted that the safety factor used in step 4 is conservative. The safety factor will increase the median size. This

will cause a larger roughness, larger flow depth and smaller flow velocity, hence a lower Froude number. Referring to Fig. 3.16, the smaller Froude number will result in a smaller value of d_{50}/depth. Despite the increase in depth, the net result is to reduce d_{50} to less than what was found in step 3. Hence, the factor of safety used in step 4 will be more than what was originally intended.

4.2 Comparison of the Riprap Sizes

The size distribution and gradation of the three riprap sizes used in this study were shown in Fig. 2.2 and Table 2.4. The three mixtures conform to the design curve from 30 percent to 100 percent. Below 30 percent the 3/4-inch size contains more fines than needed and the 2-inch size contains more coarses than needed. The 3-inch mixture conforms closely to the design curve. The difference in gradation does not seem to have a pronounced effect on the values of C_c calculated in Chapter 3, since the values found for the 2-inch and 3-inch riprap do not significantly differ from each other. However, it is clear, from both Table 3.4 and 3.5, that the values of C_c are somewhat lower for the 3/4-inch size. This can be attributed to several factors as described below.

1. The 3/4-inch riprap consisted exclusively of rounded rock, while the other two sizes consisted of crushed (angular) rock, at least in the larger sizes. This results in a lower value of Manning's roughness factor for the 3/4-inch size. It also causes less interlocking of the riprap particles in this size, hence a lower value of C_c.
2. The 3/4-inch riprap was laid only to a depth of 1.5 inches. Since the undulations of the underlying sand may be of the

order of 1.5 inches, this causes a quicker exposure of the filter blanket.

3. Since there were some fine particles in the 3/4-inch mixture, it is possible that they would accumulate in certain spots and be easily washed out. This fact is supported by a lot of patchy washouts observed for this size, shown in the appendix to the report.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A total of 48 tests were conducted on ripraps of 3/4-inch, 2-inch, and 3-inch median size at discharges of 25, 50, 75, and 100 cfs. The tests were conducted at the 8 ft tilting flume of the Hydraulics Laboratory, Engineering Research Center of Colorado State University. The flume slope was increased for each size and each discharge, until riprap failure was observed. The slope was then reduced and the test repeated to ensure stability of the riprap surface. These runs were called incipient motion runs. Depth and velocity data were collected during all runs, with more extensive data taken at the incipient motion runs. For the runs with riprap failure, size analyses of the washed material that were trapped downstream were also performed. The complete data are attached in the appendix to the report.

The preparation of the riprap material, construction of the study section, experimental facilities and data collection program were explained in Chapter 2. The data anlyses were performed in Chapter 3. Chapter 4 includes discussion of the results of data analysis. Numerous conclusions were drawn from the data analyses as listed briefly below:

1. The smooth flume walls do not have a considerable effect on the variables determined from the tests. The wall effect had to be eliminated for finding Manning's roughness factors and the critical Shields coefficients.
2. Stickler's equation underestimates Manning's roughness factor for crushed angular rocks.
3. The values of the Shields coefficient at the incipient motion conditions range from 0.022 to 0.053 for the ripraps tested in this study.

4. Angularity of the riprap material increases its resistance to motion by water.

Previous studies in relation to incipient motion of particles have been concerned with alluvial channel beds. In that case particle movement has long begun when incipient motion conditions as defined by Shields occur. For riprap, incipient motion conditions occur without significant movement of particles. Therefore, the results of previous works such as Shields diagram may not be applied to riprap. In order to obtain a comprehensive view about stability of riprap, supplemental studies are recommended in the areas listed below.

1. The effect of gradation of the riprap mixture on the stability against movement or the critical Shields coefficient needs to be studied.
2. The effect of varying Froude number on the critical Shields coefficient or the Shields diagram should be determined.
3. The performance of riprap on channel banks should be studied. The stable bank slopes for a certain riprap size and gradation and under certain ranges of Froude number or other flow variables should be determined.
4. Criteria for the stability and incipient motion of riprap surfaces should be developed through future studies. Diagrams similar to Shields may be developed for use in the design of stable ripraps.
5. The stability of a riprap surface may vary substantially under clear water flows vs. heavily sediment-laiden flows. This factor needs to be studied and the extent of its effect on stability criteria should be determined.

The items listed above require comprehensive and detailed studies in order to clarify all the concepts in existence for design of stable ripraps. The existing flumes and experimental facilities at Colorado State University have the capability of conducting detailed studies on any of the items listed above, or combining several of the items in one comprehensive study.

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APPENDIX

THE COLLECTED DATA

Appendix A - Summary

Table A-1. Summary of the Tests Conducted for the 3/4-Inch Riprap

Run No.	Orifice discharge cfs	Flume slope	Water Temperature °F	Washout Area sq.ft	Washout Area Map page (1)	Depth and velocity data page (2)	Washed sediment size analysis page (3)
1	25	0.00312	70	-	-	60	-
2		0.00470	70	1.6	70	60	94
3		0.00470	75	0.1	-	60	-
4		0.00557	79	0.7	71	60	94
5		0.00389	80	0.5	72	60	95
6	50	0.00133	80	-	-	60	-
7		0.00215	80	-	-	61	-
8		0.00307	80	38.0	73	61	95
9		0.00260	69	25.0	74	61	96
10		0.00215	73	4.0	75	61	-
11	75	0.00094	75	-	-	61	-
12		0.00152	75	-	-	62	-
13		0.00217	75	40.0	76	62	96
14		0.00183	75	12.0	77	62	97
15		0.00152	75	1.4	78	62	-
16	94	0.00095	75	-	-	62	-
17	97	0.00143	75	9.7	79	63	97
18		0.00118	77	5.0	80	63	98
19		0.00095	77	-	-	63	-

(1) Appendix C

(2) Appendix B

(3) Appendix D

Table A-2. Summary of the Tests Conducted for the 2-Inch Riprap

Run No.	Orifice discharge cfs	Flume slope	Water Temperature °F	Washout Area sq.ft	Washout Area Map page[1]	Depth and velocity data page[2]	Washed sediment size analysis page[3]
1	25	0.00852	78	-	-	63	-
2		0.01378	78	-	-	63	-
3		0.01667	75	4.0	81	64	-
4		0.01973	75	-	-	64	-
5	50	0.00761	75	-	-	64	-
6		0.01089	70	-	-	64	-
7		0.01451	70	89.0	82	64	99
8		0.01266	68	40.0	83	64	99
9		0.01089	68	2.5	84	65	100
10	75	0.00537	70	-	-	65	-
11		0.00769	70	-	-	65	-
12		0.01025	70	17.0	85	65	100
13		0.00894	72	6.0	86	65	101
14		0.00769	70	-	-	66	-
15	97	0.00420	70	-	-	66	-
16	99	0.00601	70	-	-	66	-
17		0.00801	75	33.0	87	66	101
18		0.00699	75	4.0	87	66	102
19		0.00601	75	-	-	67	-

(1) Appendix C

(2) Appendix B

(3) Appendix D

Table A-3. Summary of the Tests Conducted for the 3-Inch Riprap

Run No.	Orifice discharge cfs	Flume slope	Water Temperature °F	Washout Area sq.ft	Washout Area Map page (1)	Depth and velocity data page (2)	Washed sediment size analysis page (3)
1	25	0.02000	70	-	-	67	-
2	50	0.01544	70	-	-	67	-
3		0.02000	70	-	-	67	-
4	75	0.01500	68	4.0	89	67	102
5		0.01719	68	15.0	90	67	103
6		0.01500	72	3.5	91	68	-
7		0.01291	68	-	-	68	-
8	99	0.01009	70	-	-	68	-
9		0.01343	72	10.0	92	68	103
10		0.01172	68	0.2	-	68	-

(1) Appendix C

(2) Appendix B

(3) Appendix D

Appendix B

Depth and Velocity Data

RIPRAP SIZE=0.75 IN Q=25.CFS SLOPE=0.00312 RUN NO. 1

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.960	3.59	2.68
25.	4.	.957	3.92	2.68
40.	4.	.950	3.84	2.68

RIPRAP SIZE=0.75 IN Q=25.CFS SLOPE=0.00470 RUN NO. 2

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.872	4.17	2.93
25.	4.	.863	4.33	3.01
40.	4.	.874	4.33	2.93

RIPRAP SIZE=0.75 IN Q=25.CFS SLOPE=0.00470 RUN NO. 3

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.860	4.25	2.93
25.	4.	.842	4.33	3.09
40.	4.	.857	4.17	2.93

RIPRAP SIZE=0.75 IN Q=25.CFS SLOPE=0.00557 RUN NO. 4

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.839	4.50	3.01
25.	4.	.803	4.66	3.17
40.	4.	.841	4.50	3.01

RIPRAP SIZE=0.75 IN Q=25.CFS SLOPE=0.00389 RUN NO. 5

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	.879	4.50	4.32	3.91	3.41	2.50
10.	4.00	.879	4.32	3.99	3.74	3.33	2.75
10.	6.67	.848	4.98	4.48	3.90	3.08	2.75
25.	1.33	.891	4.56	4.40	3.99	3.49	2.43
25.	4.00	.820	4.40	4.15	3.99	3.49	2.75
25.	6.67	.885	4.73	4.23	3.90	3.25	2.42
40.	1.33	.826	4.65	4.49	4.07	3.83	2.17
40.	4.00	.856	4.40	4.32	3.91	3.50	2.59
40.	6.67	.855	4.57	4.27	3.91	3.33	2.64

RIPRAP SIZE=0.75 IN Q=50.CFS SLOPE=0.00133 RUN NO. 6

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.840	[illegible]	2.79
25.	4.	1.830	3.95	2.50
40.	4.	1.820	3.89	2.79

RIPRAP SIZE=0.75 IN Q=50.CFS SLOPE=0.00215 RUN NO. 7

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.643	4.06	3.28
25.	4.	1.584	4.22	3.23
40.	4.	1.640	4.39	3.06

RIPRAP SIZE=0.75 IN Q=50.CFS SLOPE=0.00307 RUN NO. 8

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.393	4.77	4.00
25.	4.	1.426	4.94	3.89
40.	4.	1.474	4.83	3.56

RIPRAP SIZE=0.75 IN Q=50.CFS SLOPE=0.00260 RUN NO. 9

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	1.488	4.74	4.74	4.66	4.25	3.03
10.	4.00	1.512	4.58	4.41	4.33	4.00	2.60
10.	6.67	1.467	4.74	4.91	4.74	4.17	2.93
25.	1.33	1.516	4.50	4.83	4.50	4.17	[illegible]
25.	4.00	1.471	4.74	4.50	4.33	4.00	[illegible]
25.	6.67	1.475	4.99	4.99	4.66	4.25	[illegible]
40.	1.33	1.504	4.66	4.74	4.74	3.89	[illegible]
40.	4.00	1.557	4.66	4.66	4.33	3.75	2.35
40.	6.67	1.480	4.91	4.91	4.66	4.17	3.01

RIPRAP SIZE=0.75 IN Q=50.CFS SLOPE=0.00215 RUN NO. 10

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	1.637	4.33	4.33	4.08	3.75	[illegible]
10.	4.00	1.620	4.25	4.08	3.92	3.75	[illegible]
10.	6.67	1.617	4.33	4.50	4.41	3.92	[illegible]
25.	1.33	1.610	4.50	4.50	4.37	3.84	[illegible]
25.	4.00	1.570	4.41	4.25	4.08	3.75	[illegible]
25.	6.67	1.582	4.50	4.50	4.33	3.92	2.94
40.	1.33	1.610	4.41	4.50	4.33	3.75	2.60
40.	4.00	1.630	4.50	4.41	4.00	3.59	[illegible]
40.	6.67	1.605	4.50	4.50	4.25	3.75	[illegible]

RIPRAP SIZE=0.75 IN Q=75.CFS SLOPE=0.00094 RUN NO. 11

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.647	4.00	3.26
25.	4.	2.715	4.17	3.42
40.	4.	2.678	4.08	3.17

RIPRAP SIZE=0.75 IN Q=75.CFS SLOPE=0.00152 RUN NO. 12

RIPRAP SIZE=0.75 IN Q=75.CFS SLOPE=0.00152 RUN NO. 12

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.370	4.33	3.59
25.	4.	2.372	4.91	2.84
40.	4.	2.442	4.91	3.26

RIPRAP SIZE=0.75 IN Q=75.CFS SLOPE=0.00217 RUN NO. 13

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.152	5.07	3.92
25.	4.	2.097	5.07	3.92
40.	4.	2.138	5.16	3.67

RIPRAP SIZE=0.75 IN Q=75.CFS SLOPE=0.00183 RUN NO. 14

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	2.200	4.41	4.74	4.41	3.84	3.17
10.	4.00	2.222	5.07	4.91	4.58	4.16	2.84
10.	6.67	2.223	4.66	4.83	4.66	4.33	2.93
25.	1.33	2.160	4.49	4.74	4.50	3.92	3.01
25.	4.00	2.231	5.24	5.07	4.58	4.41	[illegible]
25.	6.67	2.120	4.91	4.91	4.74	4.16	[illegible]
40.	1.33	2.190	4.58	4.83	4.41	4.17	2.84
40.	4.00	2.180	5.24	5.00	4.83	4.25	2.93
40.	6.67	2.177	4.83	4.91	4.66	4.00	3.01

RIPRAP SIZE=0.75 IN Q=75.CFS SLOPE=0.00152 RUN NO. 15

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	2.277	4.00	4.66	4.33	4.00	[illegible]
10.	4.00	2.326	4.99	4.50	4.25	3.75	3.17
10.	6.67	2.287	3.84	4.58	4.00	3.52	3.26
25.	1.33	2.364	4.17	4.50	4.25	3.67	[illegible]
25.	4.00	2.276	4.91	4.74	4.33	4.16	3.26
25.	6.67	2.230	4.16	4.58	4.41	4.16	[illegible]
40.	1.33	2.220	4.17	4.50	4.33	4.00	[illegible]
40.	4.00	2.300	4.66	4.74	4.58	4.08	3.17
40.	6.67	2.230	4.41	4.58	4.50	4.08	[illegible]

RIPRAP SIZE=0.75 IN Q=94.CFS SLOPE=0.00095 RUN NO. 16

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	[illegible]	4.74	[illegible]
25.	4.	2.992	4.74	3.75
40.	4.	2.996	4.74	3.59

RIPRAP SIZE=0.75 IN Q=97.CFS SLOPE=0.00143 RUN NO. 17

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.810	4.99	3.59
25.	4.	2.800	4.99	3.67
40.	4.	2.747	5.16	3.67

RIPRAP SIZE=0.75 IN Q=97.CFS SLOPE=0.00118 RUN NO. 18

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	2.842	4.25	4.58	4.41	3.84	2.76
10.	4.00	2.963	5.00	5.07	4.50	3.92	3.26
10.	6.67	2.832	4.66	4.83	4.83	4.33	3.34
25.	1.33	2.818	4.33	4.58	4.33	3.84	2.93
25.	4.00	2.890	5.07	4.99	4.58	4.17	2.84
25.	6.67	2.816	4.66	4.99	4.66	4.41	3.17
40.	1.33	2.747	4.33	4.66	4.41	3.92	3.09
40.	4.00	2.940	5.07	5.07	4.83	4.25	2.76
40.	6.67	2.822	4.91	4.99	4.91	4.17	3.01

RIPRAP SIZE=0.75 IN Q=97.CFS SLOPE=0.00095 RUN NO. 19

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	2.995	4.00	4.25	4.16	3.51	2.76
10.	4.00	2.995	4.83	4.83	4.41	3.75	3.01
10.	6.67	2.940	4.33	4.58	4.58	4.17	3.01
25.	1.33	2.945	4.17	4.41	4.08	3.67	2.84
25.	4.00	2.950	4.91	4.93	4.58	4.08	3.09
25.	6.67	2.952	4.50	4.74	4.66	4.08	2.76
40.	1.33	2.900	4.25	4.50	4.00	3.67	2.84
40.	4.00	2.930	4.83	4.83	4.50	4.08	3.01
40.	6.67	2.928	4.58	4.83	4.74	4.08	2.76

RIPRAP SIZE=2.00 IN Q=25.CFS SLOPE=0.00952 RUN NO. 1 .0099

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.856	4.22	2.95
25.	4.	.834	4.55	2.57
40.	4.	.776	4.55	2.90

RIPRAP SIZE=2.00 IN Q=25.CFS SLOPE=0.01378 RUN NO. 2

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.711	4.33	3.45
25.	4.	.674	5.43	4.00
40.	4.	.657	5.43	3.34

RIPRAP SIZE=2.00 IN Q=25.CFS SLOPE=0.01667 RUN NO. 3

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.640	5.27	4.11
25.	4.	.640	5.21	4.11
40.	4.	.679	5.49	3.50

RIPRAP SIZE=2.00 IN Q=25.CFS SLOPE=0.01973 RUN NO. 4

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.638	5.48	4.55
25.	4.	.642	5.82	3.99
40.	4.	.608	6.48	3.45

RIPRAP SIZE=2.00 IN Q=50.CFS SLOPE=0.00761 RUN NO. 5

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.258	5.54	3.72
25.	4.	1.186	5.87	3.69
40.	4.	1.210	5.93	3.72

RIPRAP SIZE=2.00 IN Q=50.CFS SLOPE=0.01089 RUN NO. 6

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.110	5.82	4.28
25.	4.	1.091	6.37	4.28
40.	4.	1.128	6.42	4.22

RIPRAP SIZE=2.00 IN Q=50.CFS SLOPE=0.01451 RUN NO. 7

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.180	5.93	3.39
25.	4.	.978	7.75	4.39
40.	4.	1.118	7.59	4.44

RIPRAP SIZE=2.00 IN Q=50.CFS SLOPE=0.01265 RUN NO. 8

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT [illegible] DEPTH FPS
10.	1.33	1.089	7.53	7.42	6.59	5.35	[illegible]
10.	4.00	1.103	6.70	6.37	5.65	[illegible]	[illegible]
10.	6.67	1.275	7.69	7.31	6.09	4.35	[illegible]
25.	1.33	.950	7.14	7.0[illegible]	6.70	6.04	[illegible]
25.	4.00	1.112	7.14	6.55	6.15	5.27	7.12
25.	6.67	1.016	7.91	7.53	6.48	[illegible]	[illegible]
40.	1.33	.[illegible]	8.24	7.5[illegible]	6.48	4.77	[illegible]
40.	4.00	1.1[illegible]	[illegible]	7.31	6.[illegible]	[illegible]	[illegible]
40.	6.67	1.070	7.[illegible]	7.58	6.70	5.[illegible]7	[illegible]

RIPRAP SIZE=2.00 IN Q=50.CFS SLOPE=0.01069 RUN NO. [illegible]

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	1.073	6.99	6.94	6.48	5.38	[illegible]
10.	4.00	1.199	6.54	6.31	5.76	5.1[illegible]	[illegible]
10.	6.67	1.144	7.05	6.76	6.04	4.05	1.36
25.	1.33	1.143	6.87	6.54	5.98	4.17	[illegible]
25.	4.00	1.164	6.92	6.37	5.71	4.5[illegible]	[illegible]
25.	6.67	1.150	7.03	6.54	5.87	4.7[illegible]	[illegible]
40.	1.33	1.011	7.03	6.71	5.0[illegible]	[illegible]	[illegible]
40.	4.00	1.167	6.97	6.47	5.45	4.02	[illegible]
40.	6.67	1.072	6.87	6.2[illegible]	5.49	4.37	[illegible]

RIPRAP SIZE=2.00 IN Q=75.CFS SLOPE=0.00557 RUN NO. 10

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.889	[illegible]	4.44
25.	4.	1.917	[illegible]	4.17
40.	4.	[illegible]	[illegible]	[illegible]

RIPRAP SIZE=2.00 IN Q=75.CFS SLOPE=0.00769 RUN NO. 11

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.742	6.42	4.22
25.	4.	1.745	6.76	4.00
40.	4.	1.662	6.99	3.89

RIPRAP SIZE=2.00 IN Q=75.CFS SLOPE=0.01025 RUN NO. 12

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.566	7.29	4.44
25.	4.	1.530	7.20	4.55
40.	4.	1.430	7.69	4.44

RIPRAP SIZE=2.00 IN Q=75.CFS SLOPE=0.05894 RUN NO. 13

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	1.642	6.37	6.92	6.42	5.38	[illegible]
10.	4.00	1.694	6.92	6.54	5.82	4.88	[illegible]
10.	6.67	1.609	6.98	7.09	6.20	5.21	[illegible]
25.	1.33	1.613	6.87	7.03	6.49	5.10	[illegible]
25.	4.00	1.602	7.36	6.70	6.15	5.32	[illegible]
25.	6.67	1.545	7.14	6.98	6.42	5.27	[illegible]
40.	1.33	1.624	6.76	6.76	6.29	4.83	[illegible]
40.	4.00	1.525	4.74	6.84	6.09	4.94	[illegible]
40.	6.67	1.584	6.76	6.76	6.15	4.66	[illegible]

RIPRAP SIZE=2.00 IN Q=75.CFS SLOPE=0.00769 RUN NO. 14

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	1.745	6.20	6.59	6.15	4.88	1.63
10.	4.00	1.830	6.70	6.26	5.76	4.66	3.34
10.	6.67	1.740	6.37	6.46	5.82	4.77	3.17
25.	1.33	1.637	6.59	6.75	6.26	5.16	3.45
25.	4.00	1.644	7.25	6.70	6.09	4.65	2.18
25.	6.67	1.584	6.98	5.98	6.42	5.10	3.33
40.	1.33	1.694	6.65	6.65	5.76	4.17	2.51
40.	4.00	1.681	7.09	6.54	5.71	4.99	2.46
40.	6.67	1.741	6.70	6.70	5.87	4.77	3.34

RIPRAP SIZE=2.00 IN Q=97.CFS SLOPE=0.00420 RUN NO. 15

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.385	6.54	4.06
25.	4.	2.317	6.81	4.00
40.	4.	2.273	6.81	4.11

RIPRAP SIZE=2.00 IN Q=99.CFS SLOPE=0.00601 RUN NO. 16

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.145	6.48	3.64
25.	4.	2.069	7.39	3.89
40.	4.	2.120	6.97	3.78

RIPRAP SIZE=2.00 IN Q=99.CFS SLOPE=0.00601 RUN NO. 17

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.034	7.59	4.35
25.	4.	1.997	7.64	4.33
40.	4.	2.000	7.69	4.55

RIPRAP SIZE=2.00 IN Q=95.CFS SLOPE=0.00699 RUN NO. 18

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	2.095	6.31	6.87	6.31	5.27	[illegible]
10.	4.00	2.077	7.53	7.03	6.20	4.54	[illegible]
10.	6.67	1.971	6.93	7.42	6.61	5.45	[illegible]
25.	1.33	2.004	6.92	6.95	6.55	[illegible]	[illegible]
25.	4.00	1.997	7.97	7.31	6.43	5.54	[illegible]
25.	6.67	1.906	7.47	7.31	6.81	[illegible]	[illegible]
40.	1.33	2.070	7.03	7.09	6.04	4.50	[illegible]
40.	4.00	2.000	7.59	7.14	6.05	[illegible]	[illegible]
40.	6.67	2.090	[illegible]	7.13	[illegible]	[illegible]	[illegible]

RIPRAP SIZE=[illegible] IN Q=[illegible].CFS SLOPE=0.00[illegible] RUN NO. 1[illegible]

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT [illegible] DEPTH FPS	VELOCITY AT [illegible] DEPTH FPS	VELOCITY AT [illegible] DEPTH	VELOCITY AT [illegible] DEPTH FPS
10.	1.33	2.174	5.67	[illegible]	[illegible]		[illegible]
10.	4.00	2.115	6.9[illegible]	[illegible]	[illegible]		[illegible]
10.	6.67	2.12[illegible]	6.4[illegible]	7.0[illegible]	[illegible]		[illegible]
25.	1.3[illegible]	2.041	6.4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25.	4.00	1.9[illegible]	7.3[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25.	6.67	2.03[illegible]	6.96	7.3[illegible]	6.7[illegible]	[illegible]	[illegible]
40.	1.33	2.11[illegible]	6.4[illegible]	7.3[illegible]	[illegible]	[illegible]	[illegible]
40.	4.00	1.9[illegible]	7.47	6.5[illegible]	[illegible]	[illegible]	[illegible]
40.	6.67	2.01[illegible]	7.2[illegible]	7.3[illegible]	[illegible]	[illegible]	[illegible]

RIPRAP SIZE=3.00 IN Q=25.CFS SLOPE=0.02000 RUN NO. 1

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.706	5.19	1.65
25.	4.	.716	5.38	3.28
40.	4.	.541	6.37	5.21

RIPRAP SIZE=3.00 IN Q=50.CFS SLOPE=0.01544 RUN NO. 2

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.123	5.87	3.85
25.	4.	1.029	7.20	4.66
40.	4.	1.041	7.20	4.50

RIPRAP SIZE=3.00 IN Q=50.CFS SLOPE=0.02000 RUN NO. 3

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.105	6.09	4.17
25.	4.	1.021	7.47	4.63
40.	4.	.951	7.97	6.04

RIPRAP SIZE=3.00 IN Q=75.CFS SLOPE=0.01500 RUN NO. 4

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.446	7.20	5.10
25.	4.	1.335	7.75	5.43
40.	4.	1.263	8.50	5.60

RIPRAP SIZE=3.00 IN Q=75.CFS SLOPE=0.01719 RUN NO. 5

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.397	7.80	5.87
25.	4.	1.391	5.19	5.21
40.	4.	1.301	7.75	4.50

RIPRAP SIZE=3.00 IN Q=75.CFS SLOPE=0.01500 RUN NO. 6

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	1.431	7.14	7.14	7.09	6.42	4.93
10.	4.00	1.410	7.35	7.03	6.65	6.04	3.89
10.	6.67	1.328	7.97	7.64	7.31	6.54	4.59
25.	1.33	1.332	8.03	7.86	7.47	5.98	4.72
25.	4.00	1.442	8.02	7.91	7.03	6.09	4.28
25.	6.67	1.405	8.41	7.91	7.36	6.44	4.66
40.	1.33	1.380	8.13	8.13	7.75	5.82	3.72
40.	4.00	1.422	8.08	7.69	6.98	6.15	4.44
40.	6.67	1.334	8.90	8.02	7.09	6.15	4.84

RIPRAP SIZE=3.00 IN Q=75.CFS SLOPE=0.01291 RUN NO. 7

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	1.445	7.09	7.03	6.81	6.15	4.61
10.	4.00	1.393	7.14	6.81	6.20	5.71	3.95
10.	6.67	1.385	7.75	7.64	7.09	6.42	4.22
25.	1.33	1.364	7.66	7.69	7.36	6.20	4.39
25.	4.00	1.443	7.47	7.03	6.37	5.49	3.17
25.	6.67	1.427	7.66	7.65	6.98	6.20	4.83
40.	1.33	1.380	7.86	7.86	7.09	5.65	3.50
40.	4.00	1.427	7.80	7.25	6.31	5.49	3.93
40.	6.67	1.338	8.52	8.08	7.25	6.15	4.21

RIPRAP SIZE=3.00 IN Q=95.CFS SLOPE=0.01009 RUN NO. 8

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.698	7.58	4.83
25.	4.	1.325	7.53	4.72
40.	4.	1.420	7.86	4.33

RIPRAP SIZE=3.00 IN Q=95.CFS SLOPE=0.01343 RUN NO. 9

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.789	7.86	5.27
25.	4.	1.723	7.97	4.68
40.	4.	1.598	8.35	4.88

RIPRAP SIZE=3.00 IN Q=99.CFS SLOPE=0.01172 RUN NO. 10

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	1.748	7.03	7.47	7.25	6.54	4.66
10.	4.00	1.817	8.02	7.53	6.47	5.71	4.38
10.	6.67	1.847	7.47	7.69	7.14	6.15	4.28
25.	1.33	1.737	7.31	7.58	7.20	6.15	[illegible]
25.	4.00	1.634	8.24	7.47	6.76	5.41	3.91
25.	6.67	1.755	7.91	8.02	7.25	6.54	4.43
40.	1.33	1.652	7.31	7.58	6.98	5.19	3.51
40.	4.00	1.503	7.91	7.47	6.42	5.45	3.79
40.	6.67	1.841	8.04	7.97	7.20	5.82	4.17

Appendix C

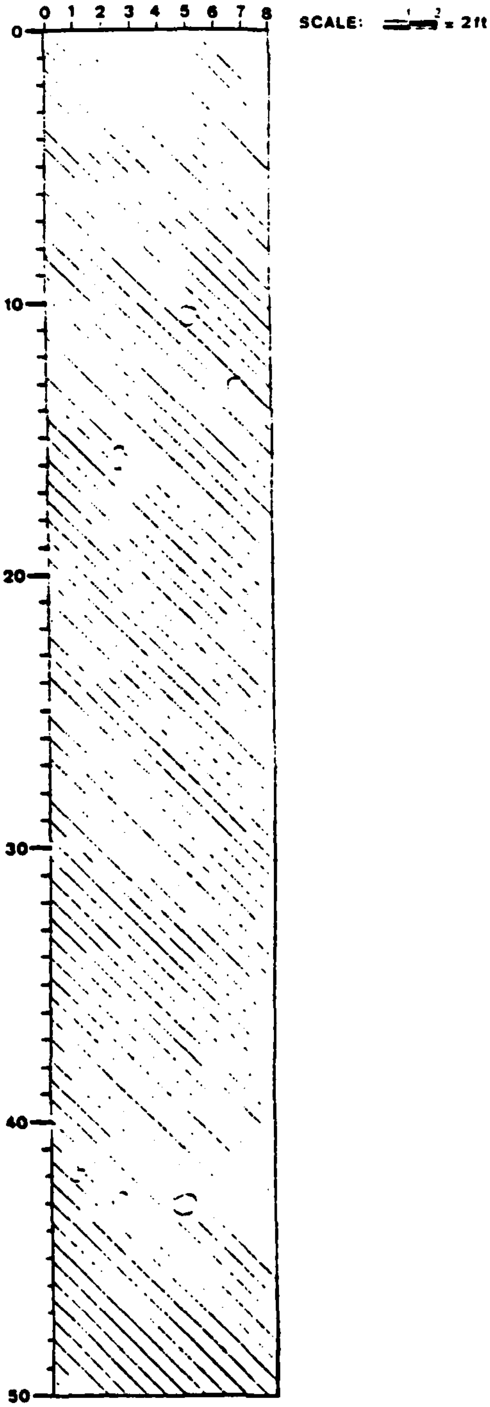
Maps of Washout Areas

RIPRAP SIZE: .75 in.

RUN NO: 2

DISCHARGE: 25 cfs

SLOPE: 470 $\times 10^{-5}$

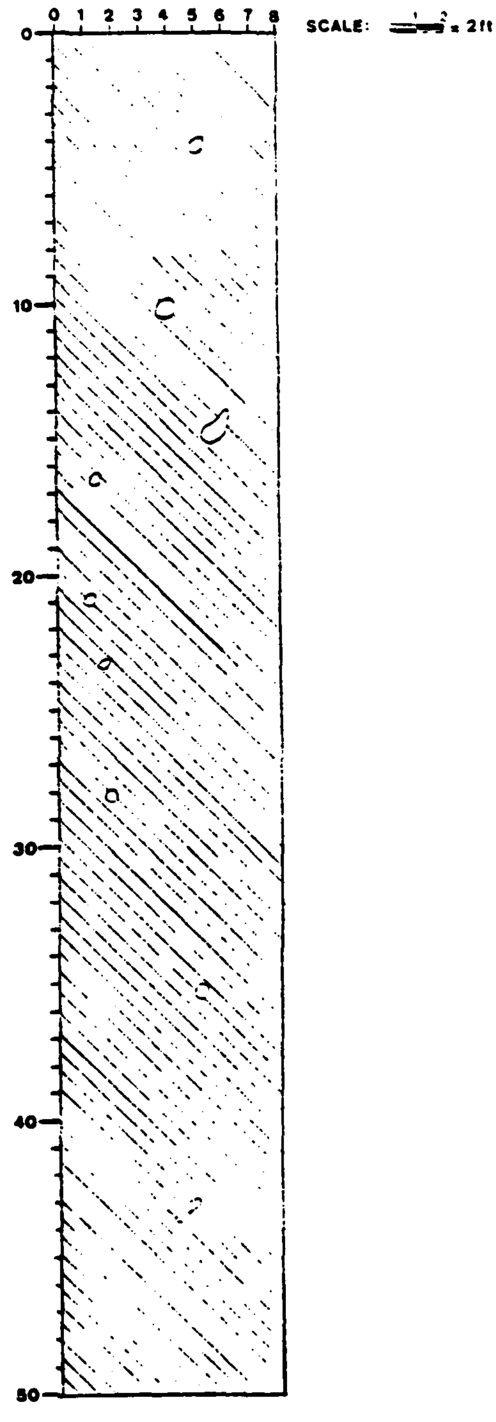


RIPRAP SIZE: .75 in.

RUN NO: 4

DISCHARGE: 25 cfs

SLOPE: 587×10^{-5}

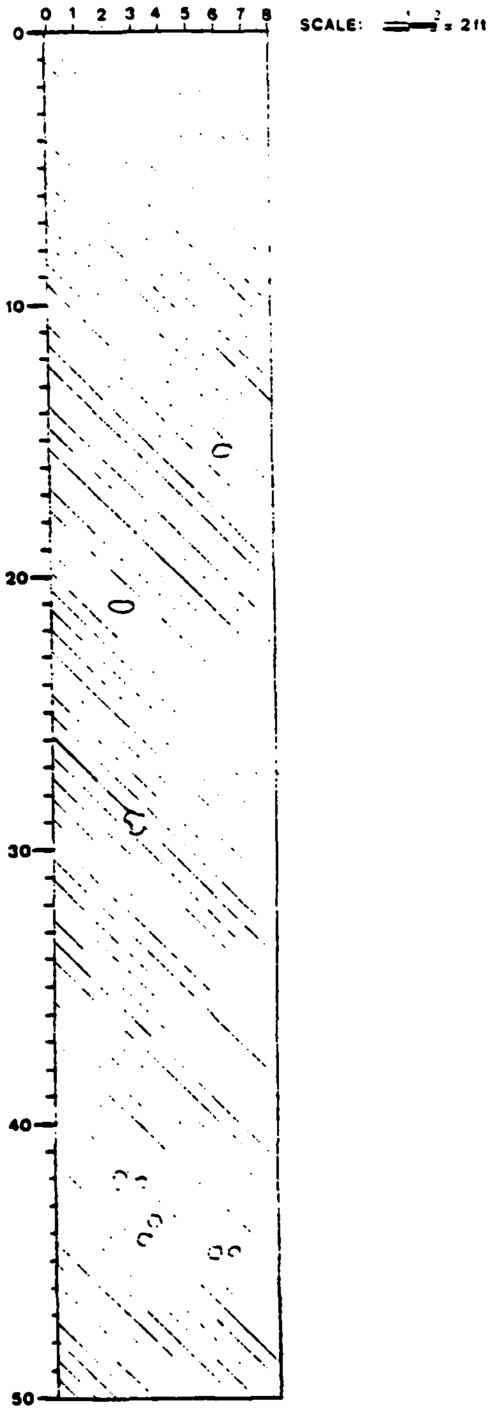


RIPRAP SIZE: .75 in.

RUN NO: 5

DISCHARGE: 25 cfs

SLOPE: 389 $\times 10^{-5}$

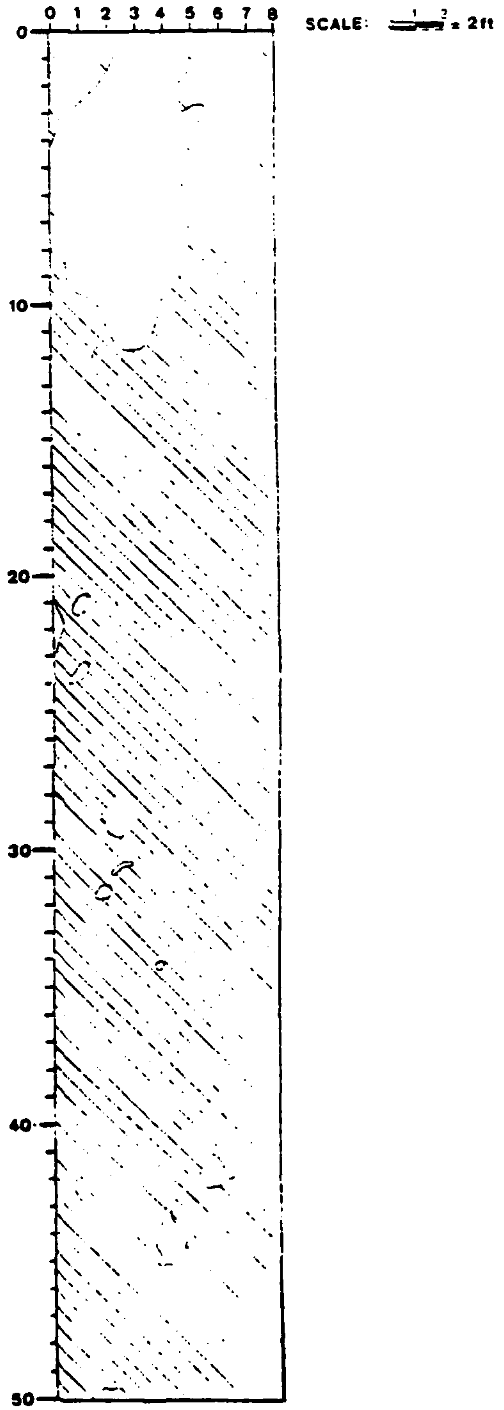


RIPRAP SIZE: .75 in.

RUN NO: 8

DISCHARGE: 50 cfs

SLOPE: 307 x 10^{-5}

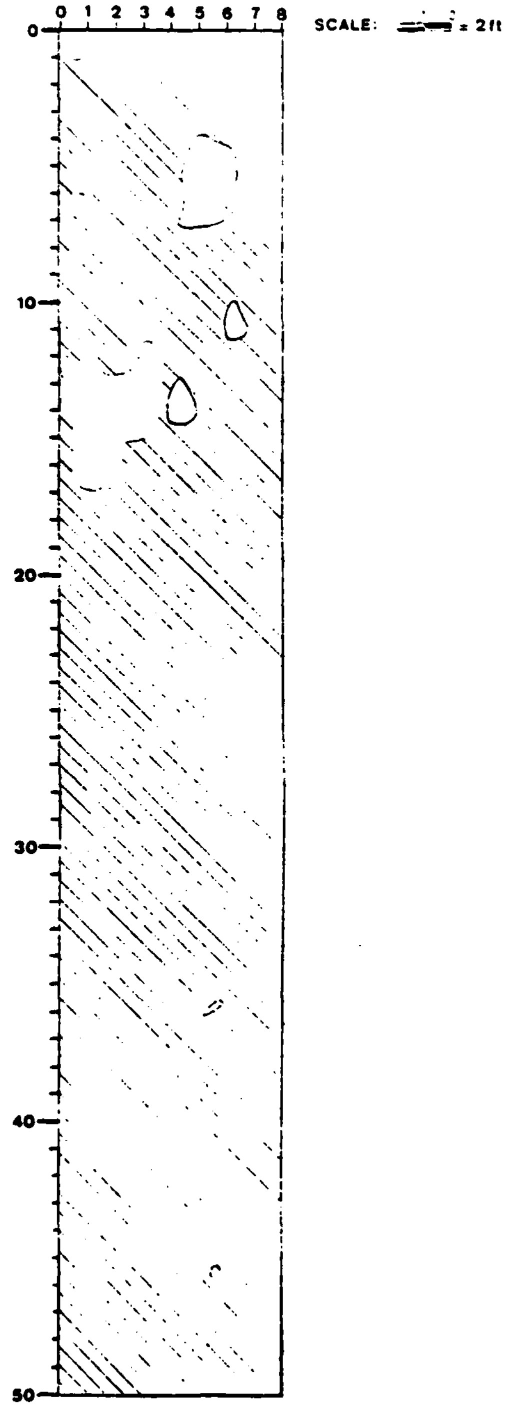


RIPRAP SIZE: .75 in.

RUN NO: 9

DISCHARGE: 50 cfs

SLOPE: 260 $\times 10^{-5}$

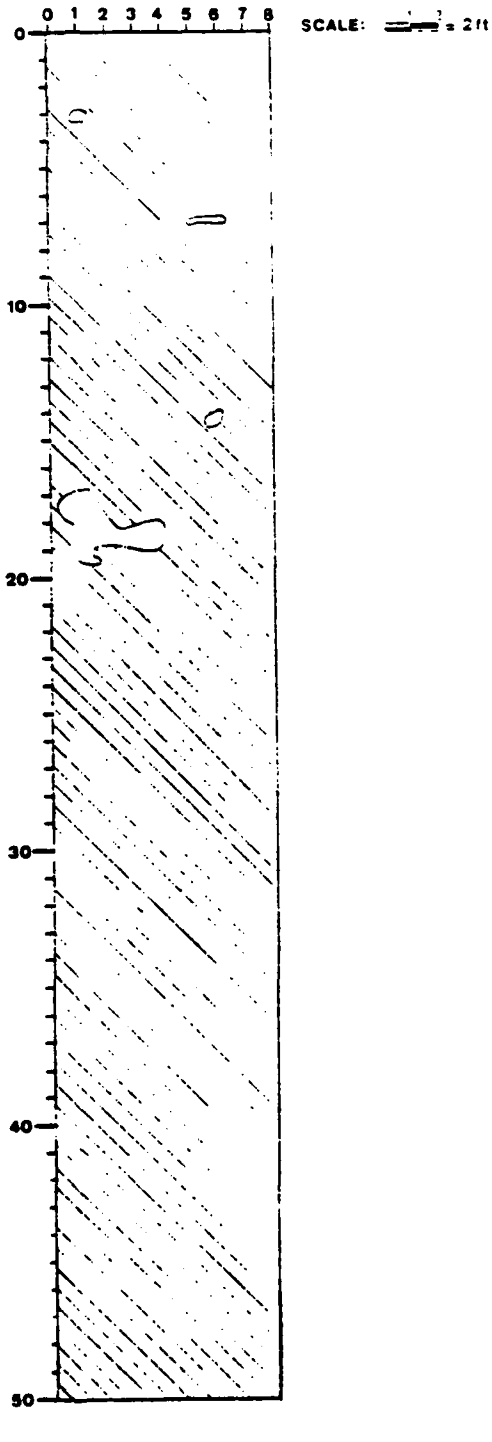


RIPRAP SIZE: .75 in.

RUN NO: 10

DISCHARGE: 50 cfs

SLOPE: 215×10^{-5}



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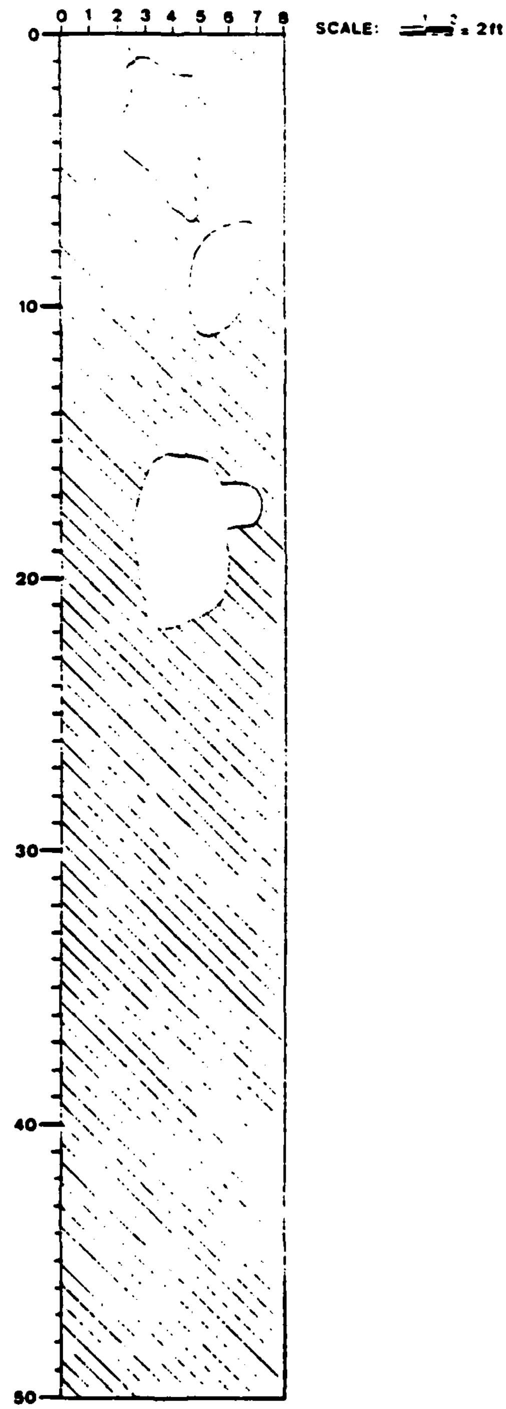
RUN NO: 13

DISCHARGE: 75 cfs

SLOPE: 217×10^{-5}



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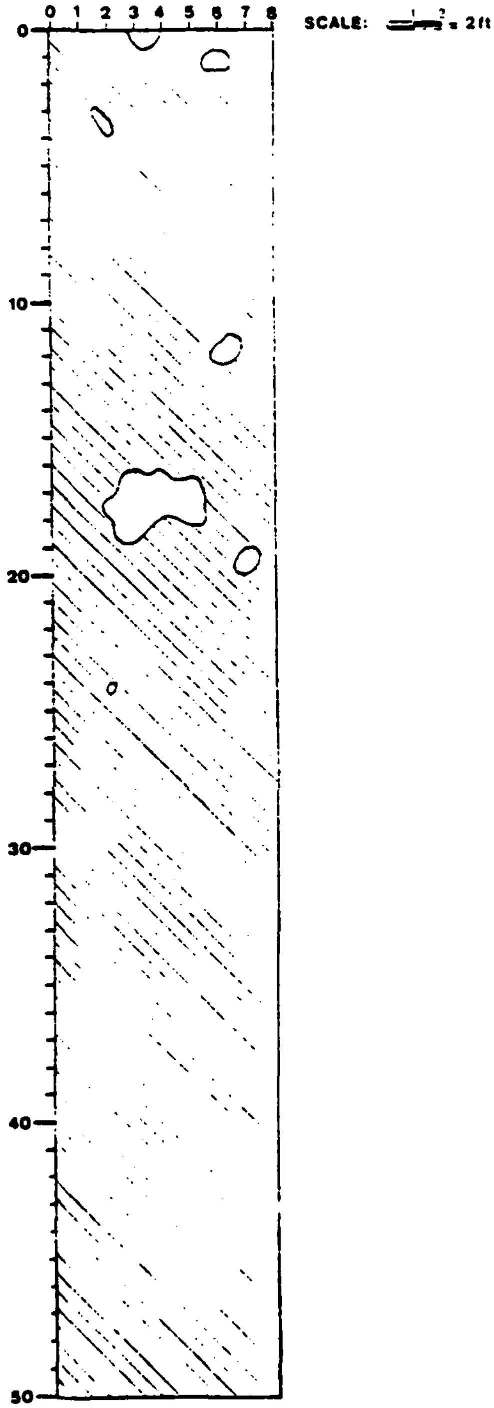
RUN NO: 14

DISCHARGE: 75 cfs

SLOPE: 183 $\times 10^{-5}$



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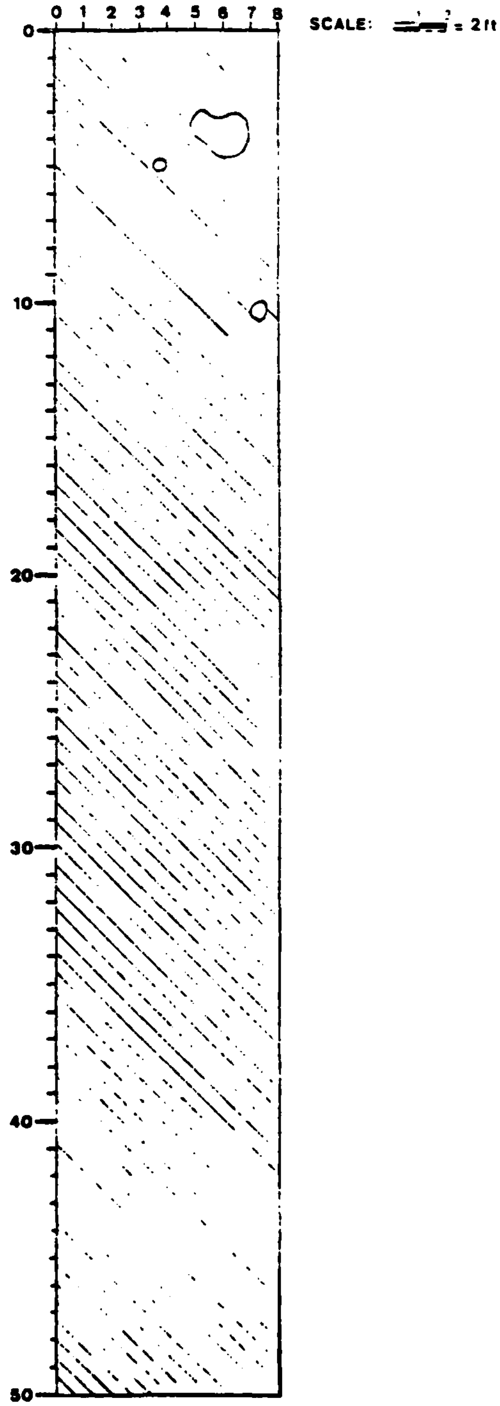
RUN NO: 15

DISCHARGE: 75 cfs

SLOPE: 152 $\times 10^{-5}$



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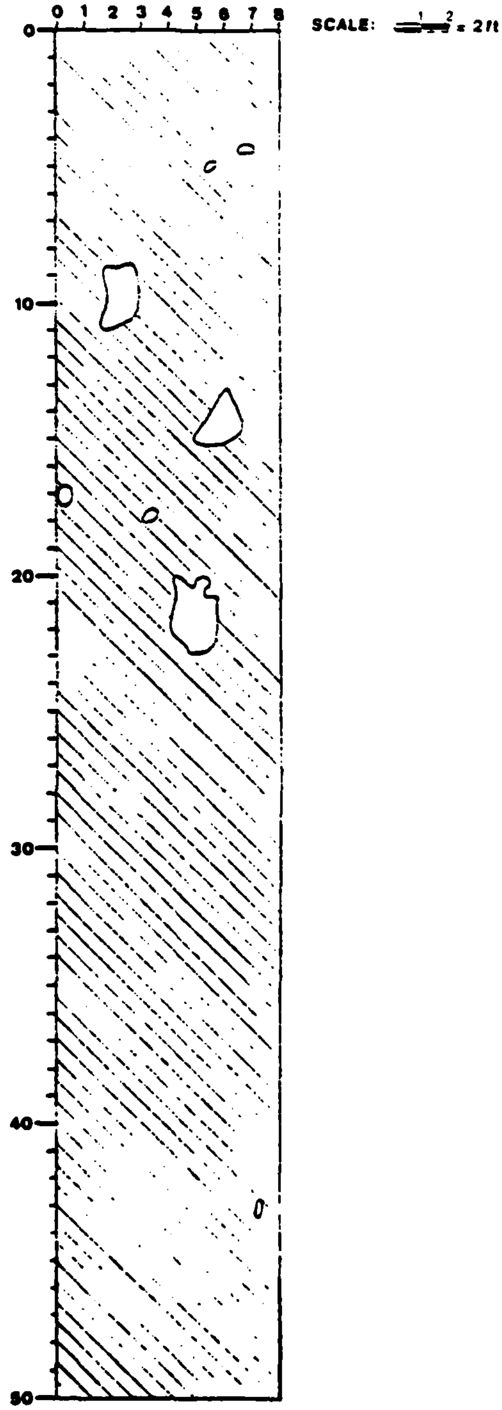
RUN NO: 17

DISCHARGE: 97 cfs

SLOPE: 143×10^{-5}

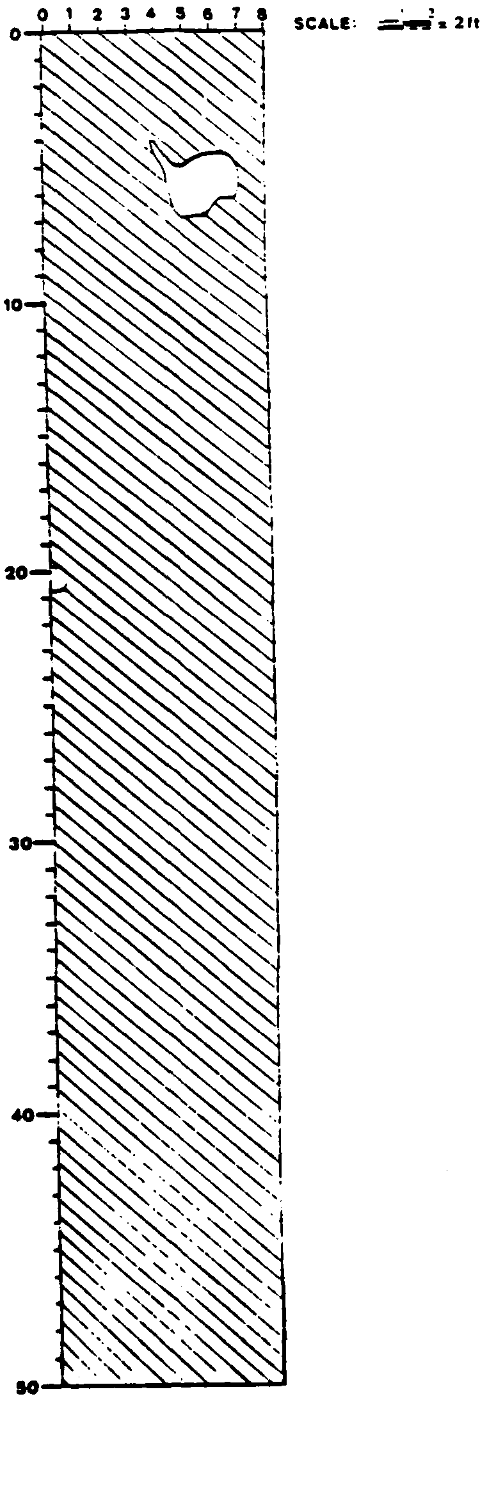


RIPRAP SIZE: .75 in.

RUN NO: 18

DISCHARGE: 97 cfs

SLOPE: 118 x10^{-5}

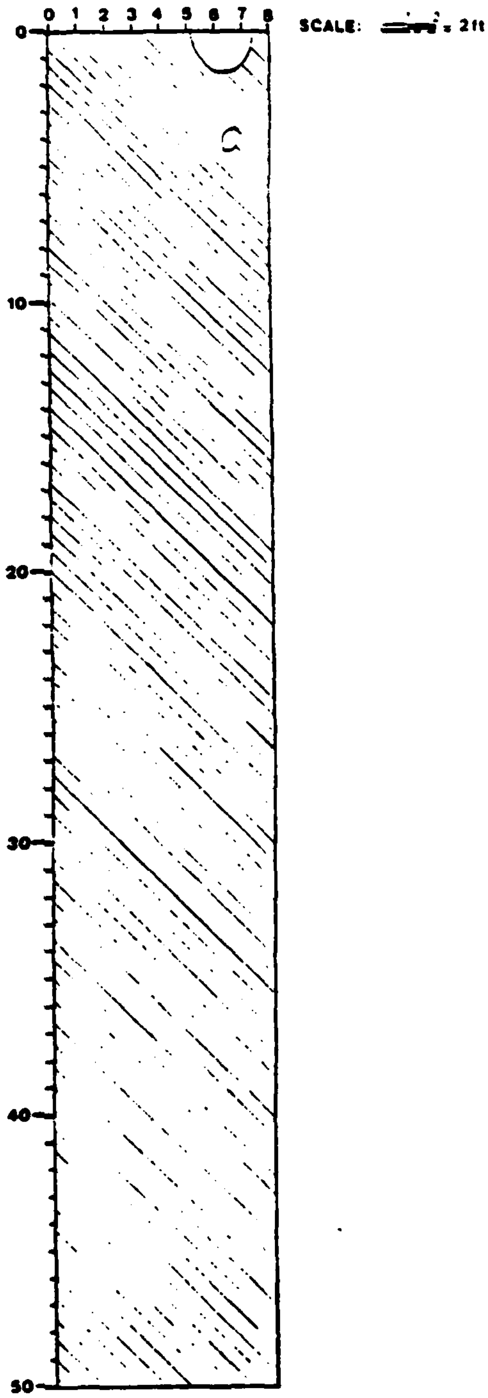


RIPRAP SIZE: 2.0 in.

RUN NO: 3

DISCHARGE: 25 cfs

SLOPE: 1667 $\times 10^{-5}$

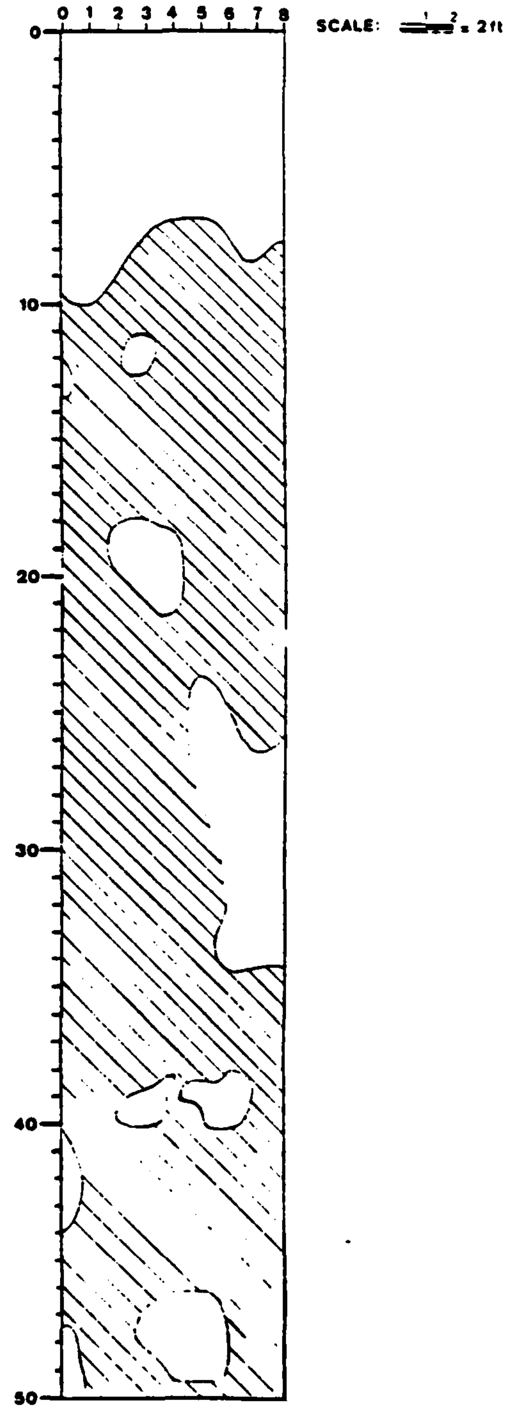


RIPRAP SIZE: 2.0 in.

RUN NO: 7

DISCHARGE: 50 cfs

SLOPE: 1451×10^{-5}

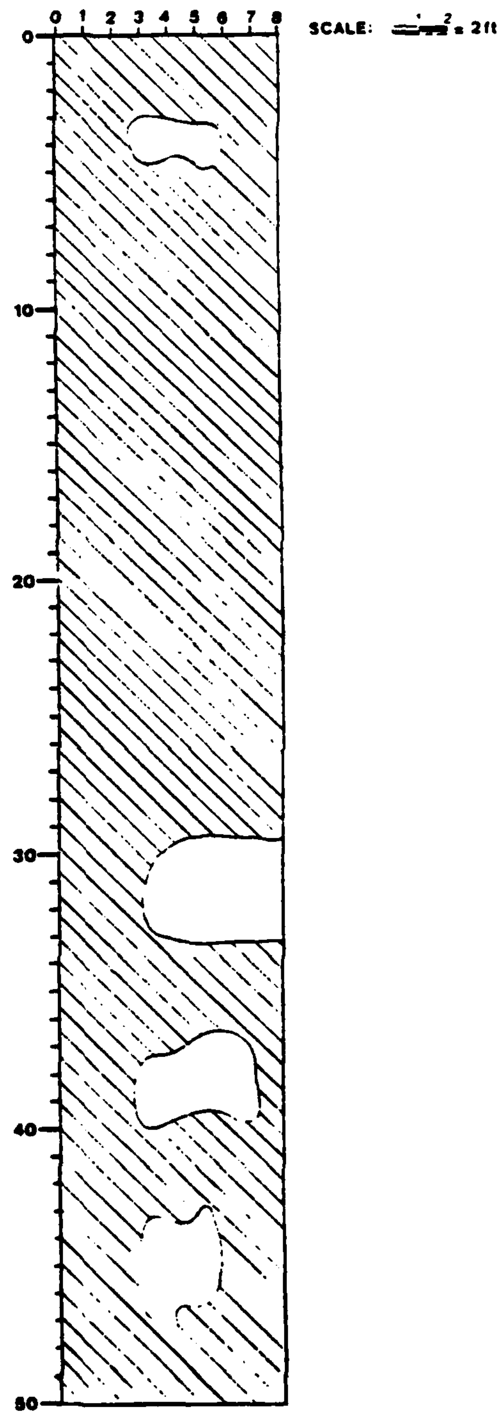


RIPRAP SIZE: 2.0 in.

RUN NO: 6

DISCHARGE: 50 cfs

SLOPE: 1089×10^{-5}



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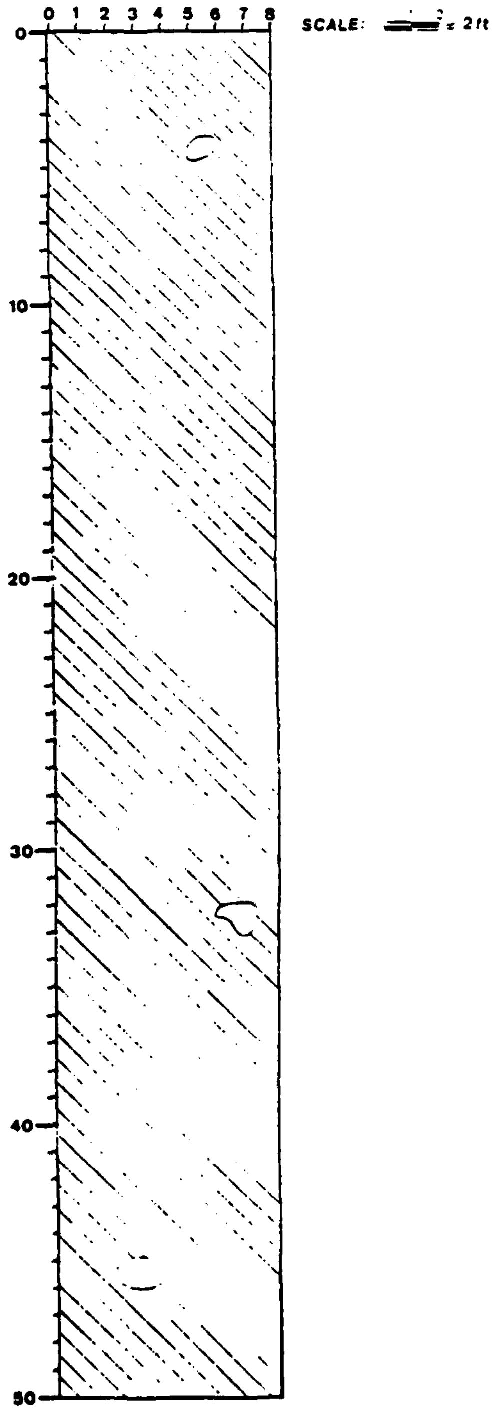
RUN NO: 9

DISCHARGE: 50 cfs

SLOPE: 1089×10^{-5}

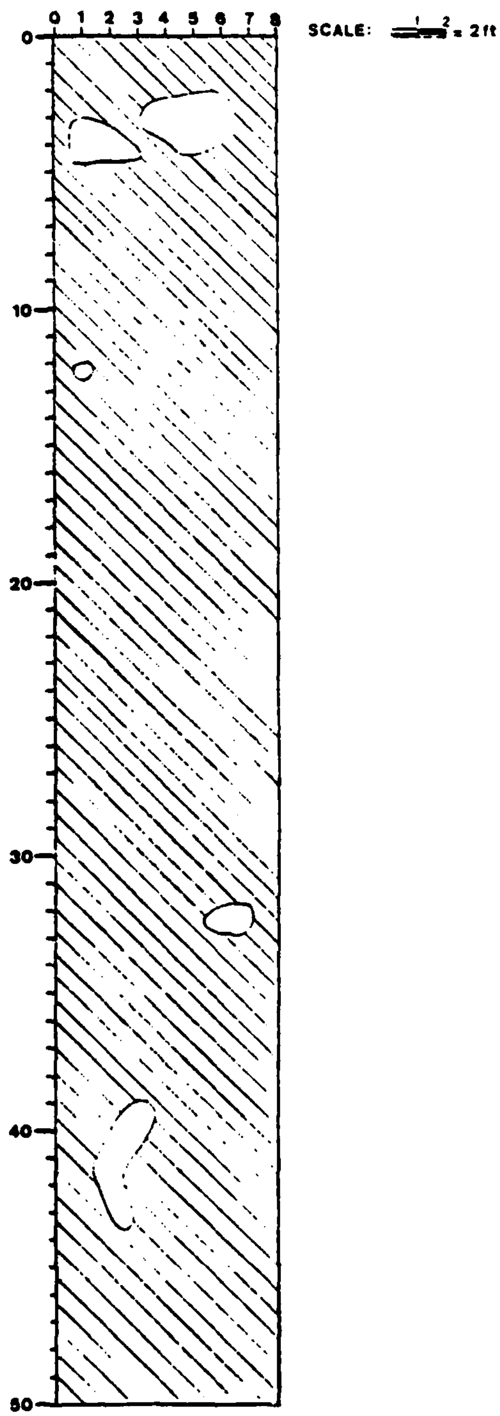


RIPRAP SIZE: 2.0 in.

RUN NO: 12

DISCHARGE: 75 cfs

SLOPE: 1025×10^{-5}

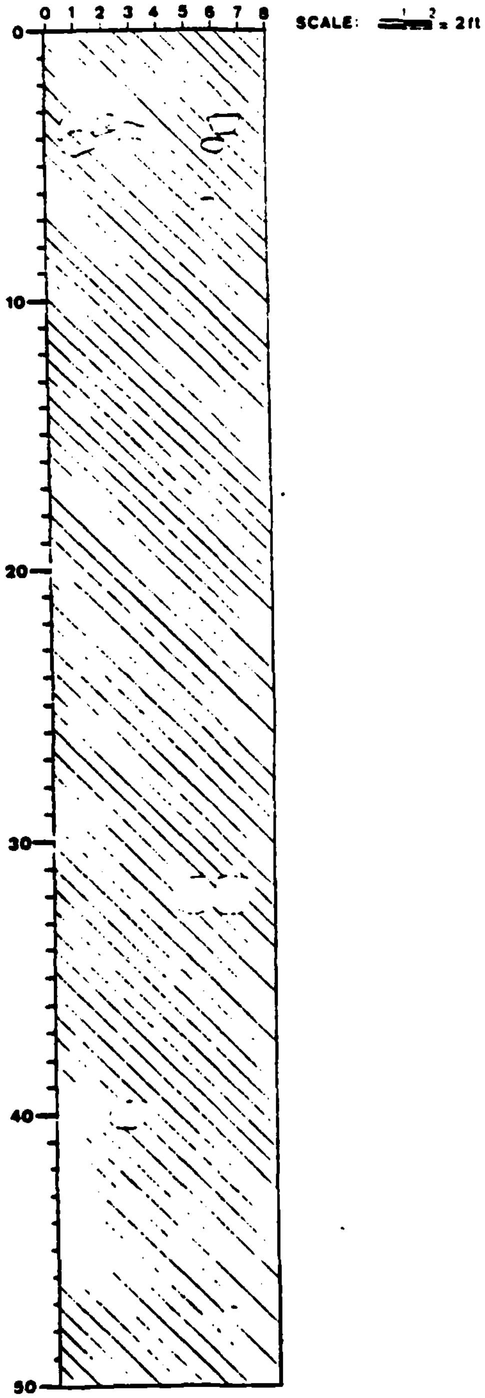


RIPRAP SIZE: 2.0 in.

RUN NO: 13

DISCHARGE: 75 cfs

SLOPE: 894 x 10^{-5}

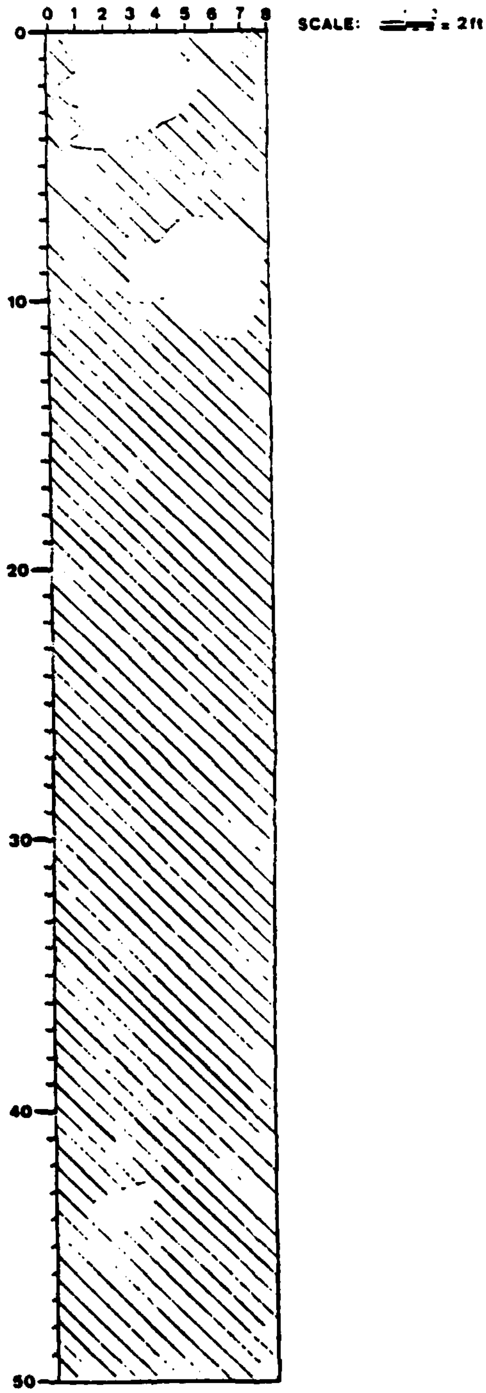


RIPRAP SIZE: 2.0 in.

RUN NO: 17

DISCHARGE: 99 cfs

SLOPE: 801 x 10^{-5}

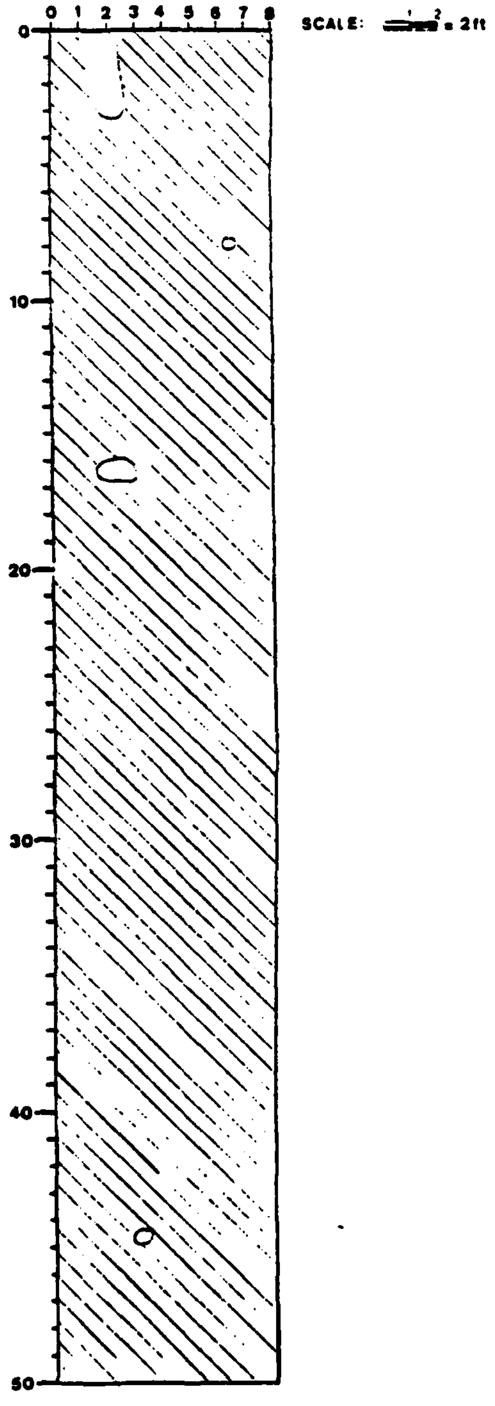


RIPRAP SIZE: 2.0 in.

RUN NO: 18

DISCHARGE: 100 cfs

SLOPE: 699×10^{-5}

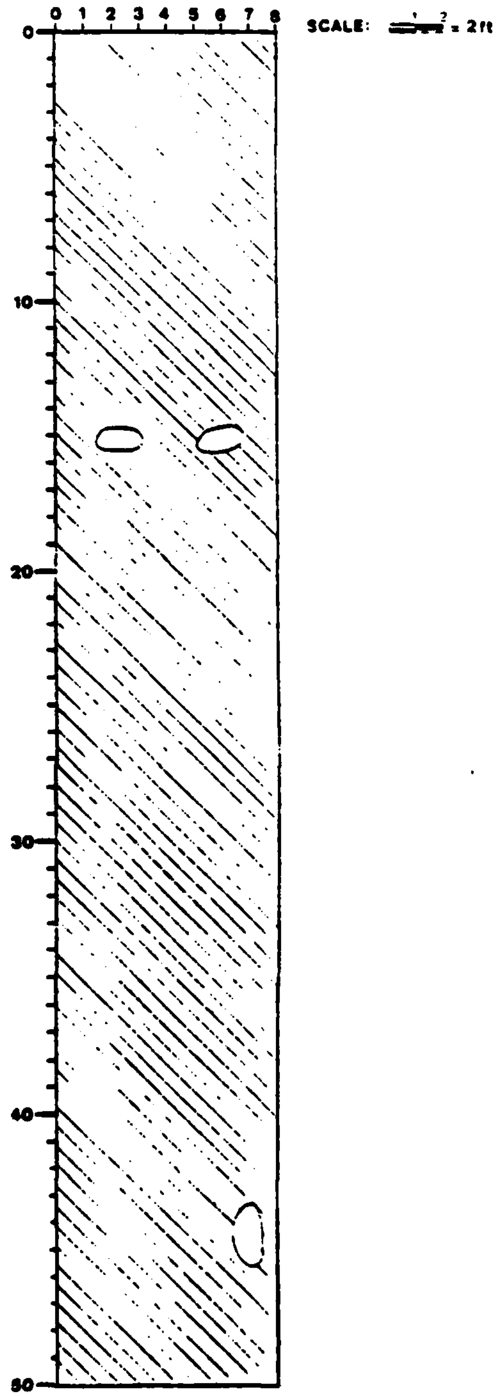


RIPRAP SIZE: 3.0 in.

RUN NO: 4

DISCHARGE: 75 cfs

SLOPE: 150×10^{-5}

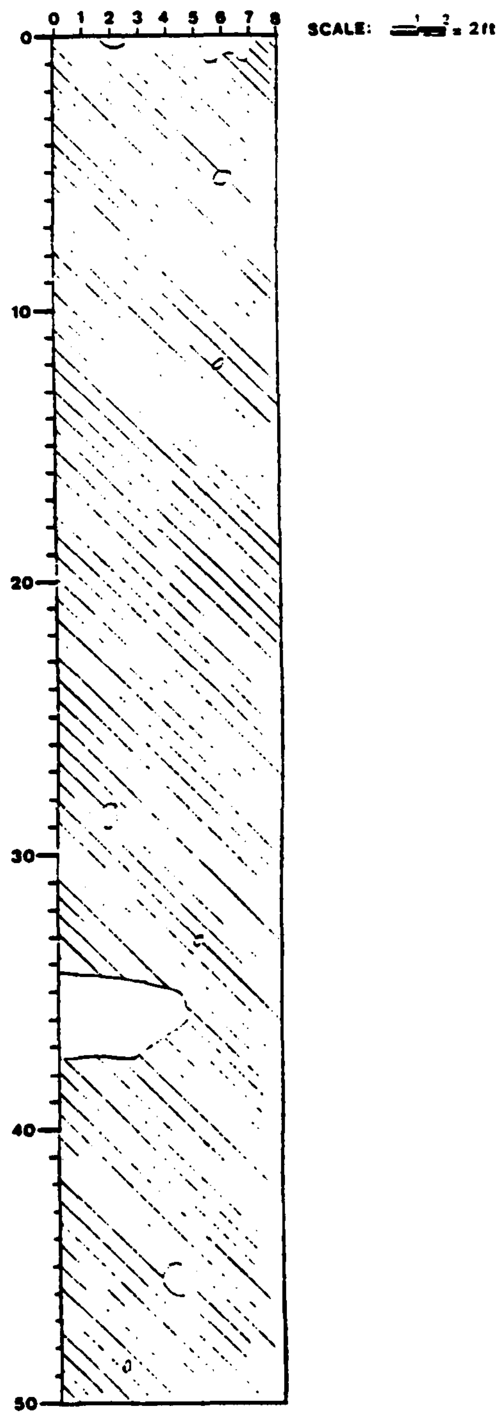


RIPRAP SIZE: 3.0 in.

RUN NO: 5

DISCHARGE: 75 cfs

SLOPE: 1719×10^{-5}

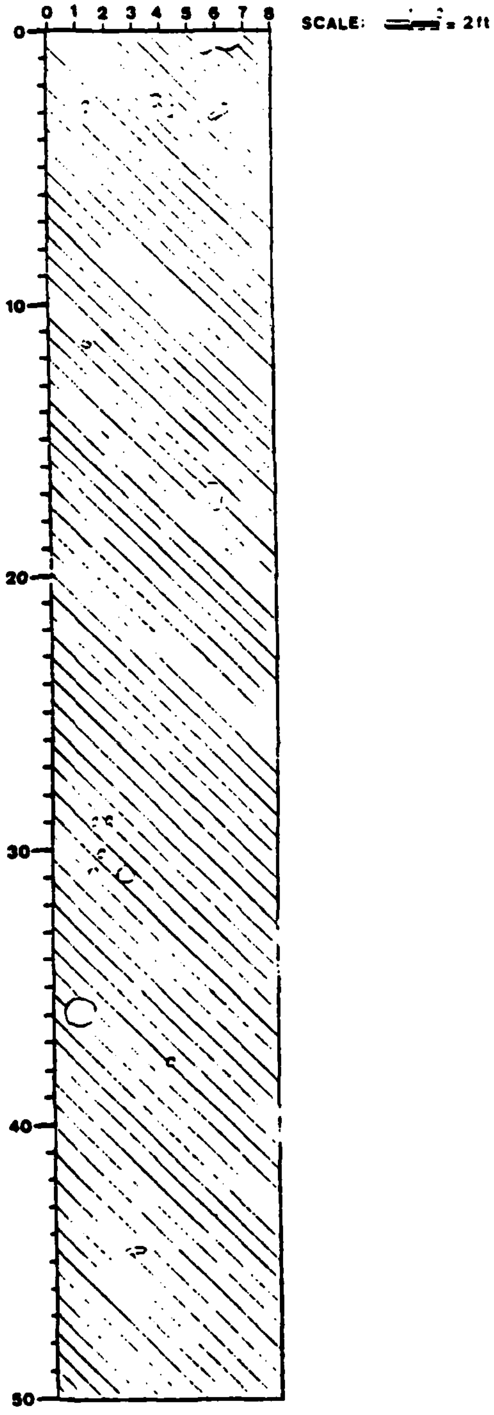


RIPRAP SIZE: 3.0 in.

RUN NO: 6

DISCHARGE: 75 cfs

SLOPE: 1500×10^{-5}

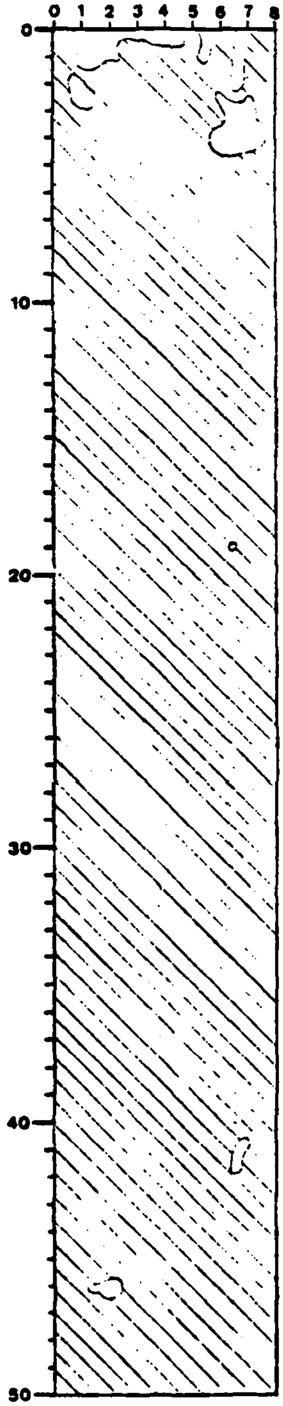


RIPRAP SIZE: 3.0 in.

RUN NO: 9

DISCHARGE: 100 cfs

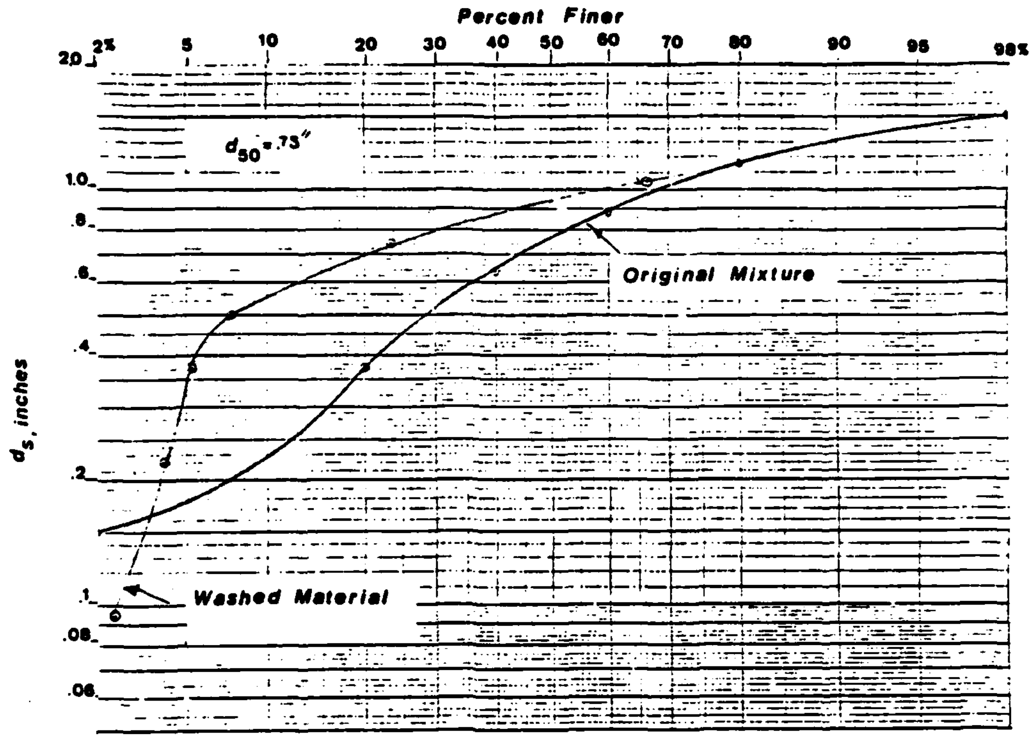
SLOPE: 1343×10^{-5}



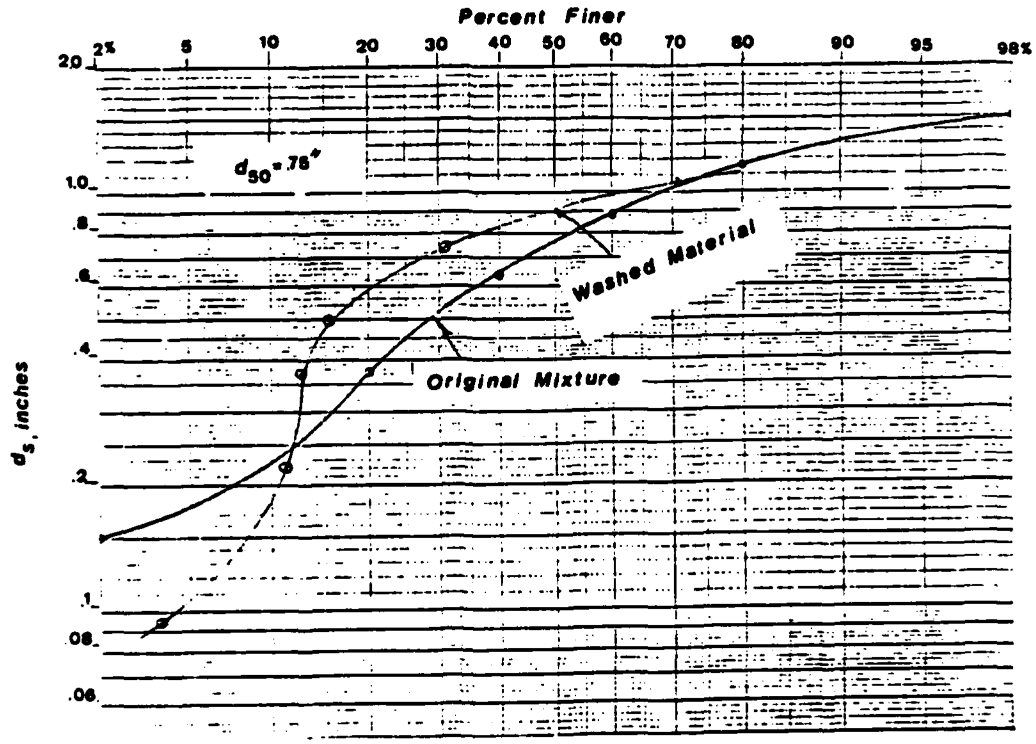
SCALE: 1 2 = 2 ft

Appendix D

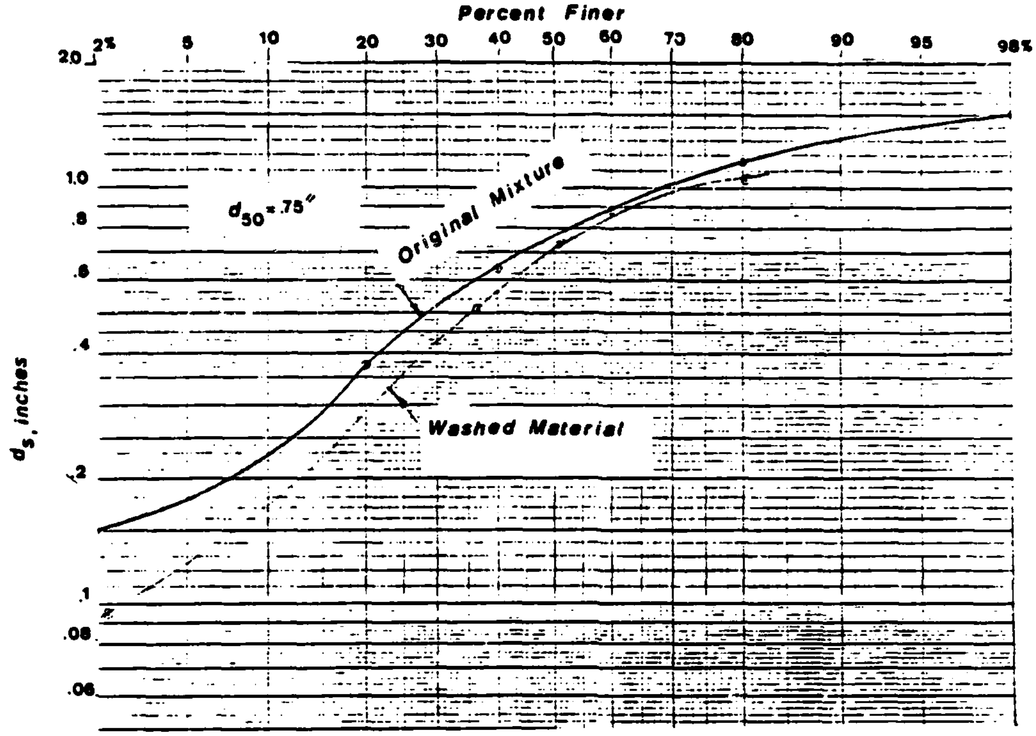
Analysis of Washed Sediment Sizes



Run No. 2



Run No. 4



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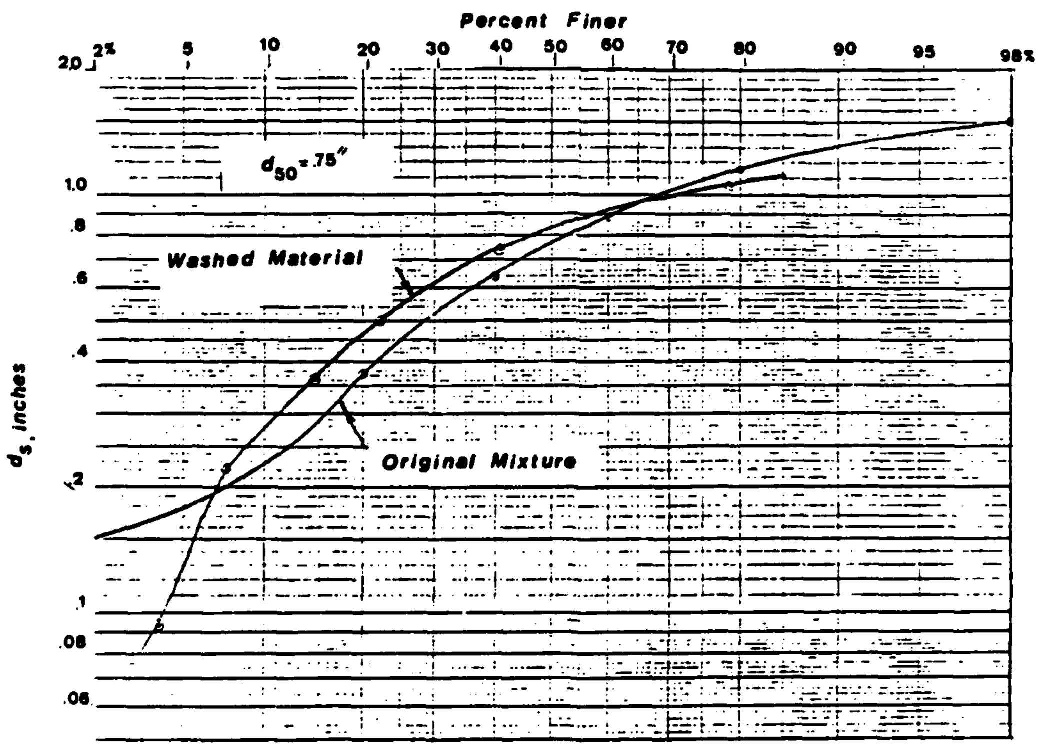
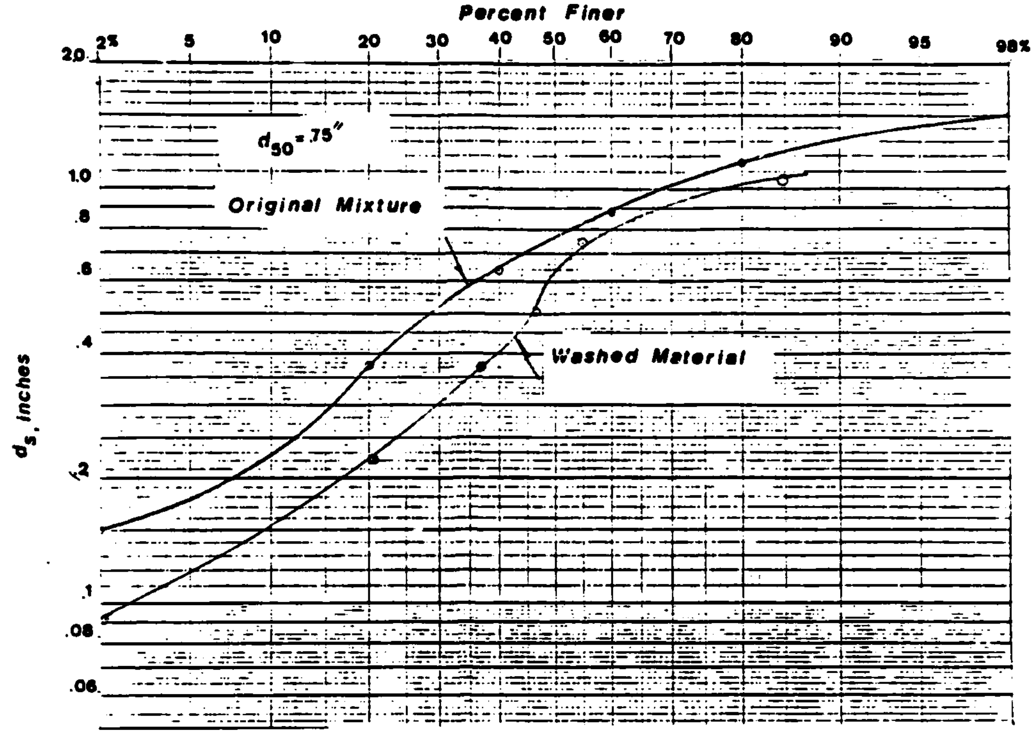
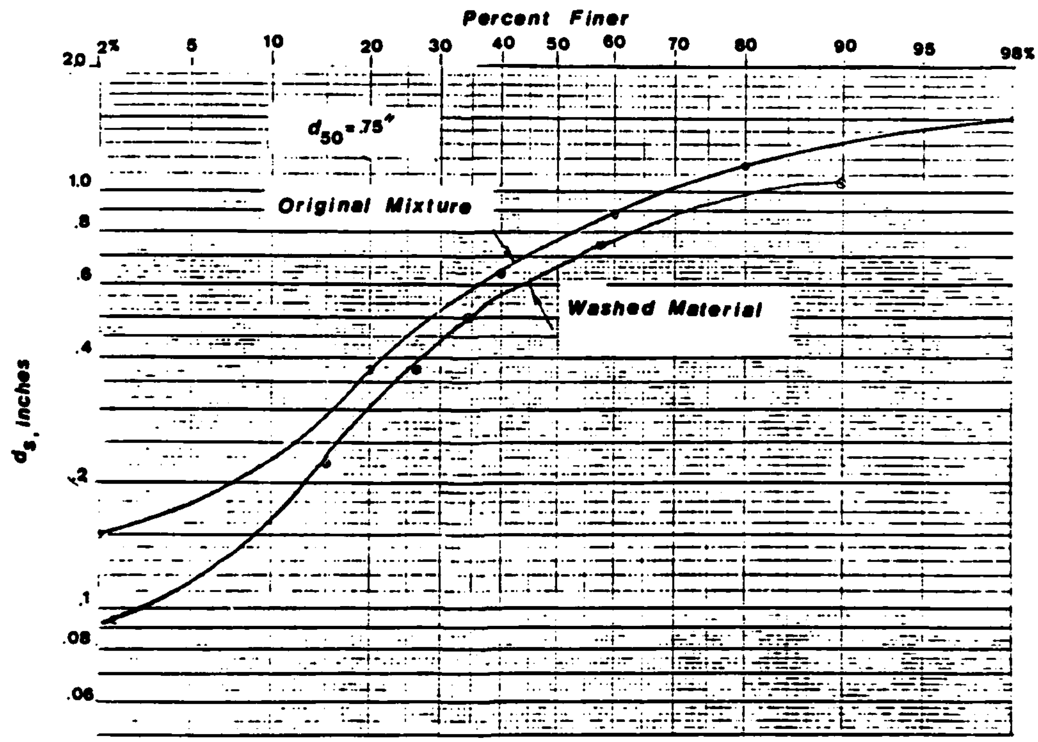


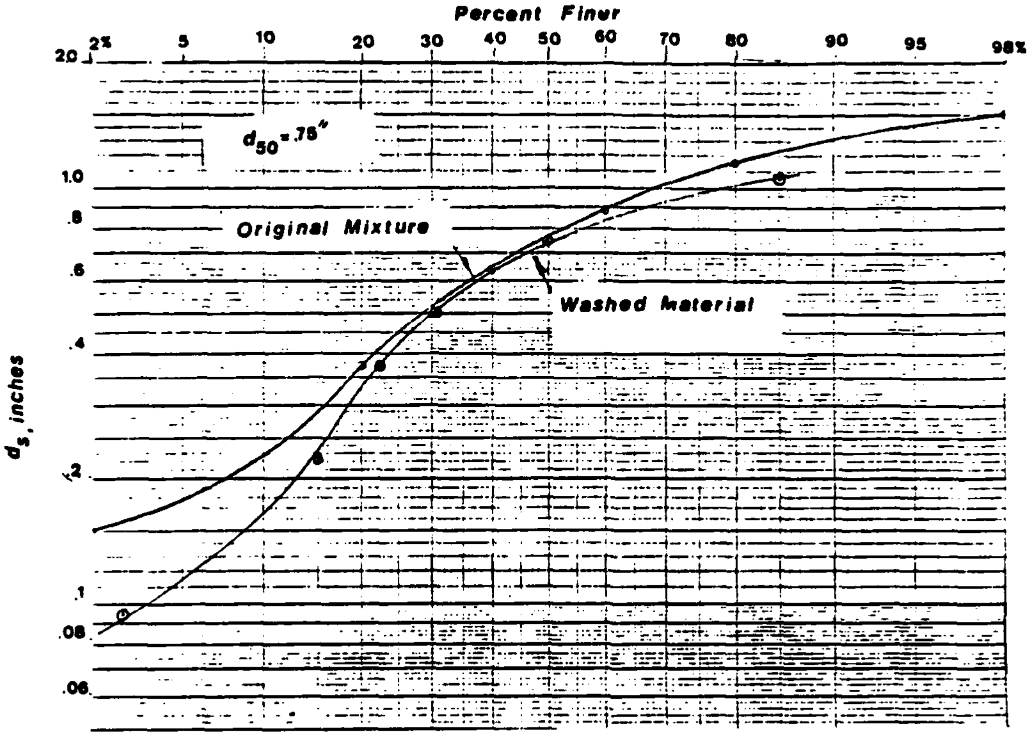
Run No. 8



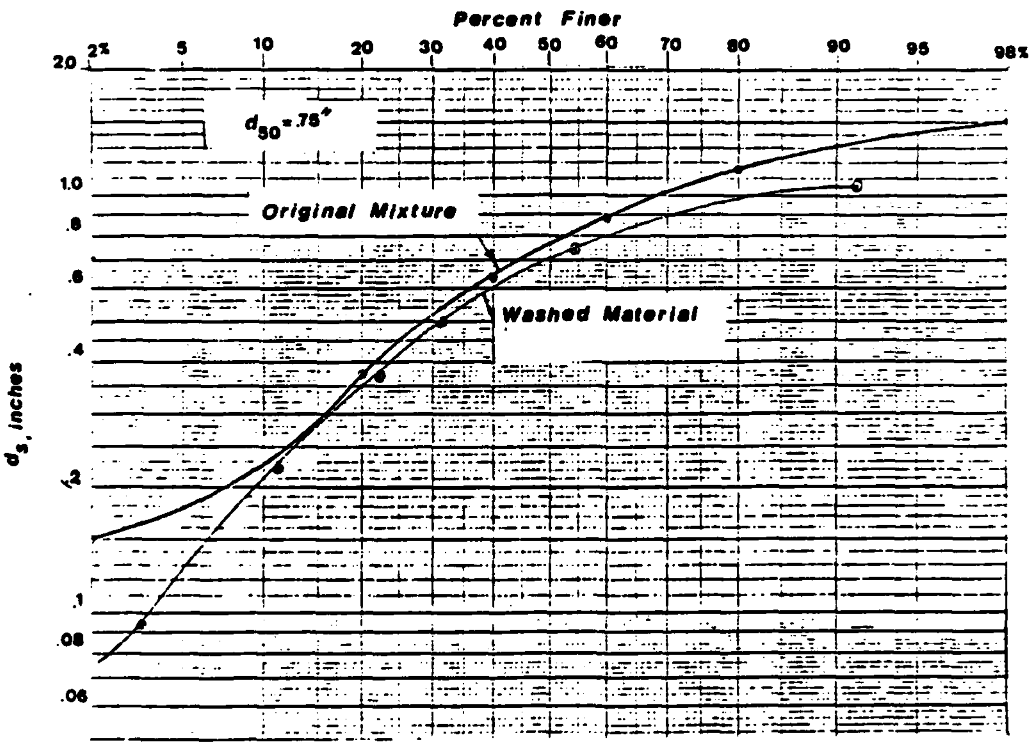
Run No. 9



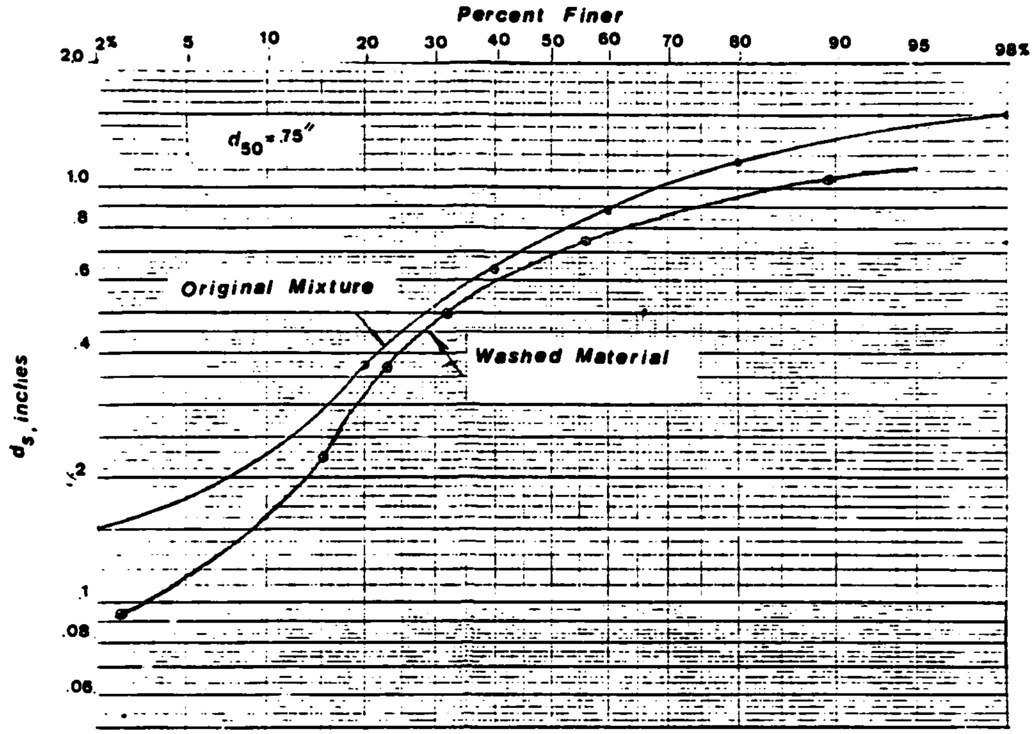
Run No. 13



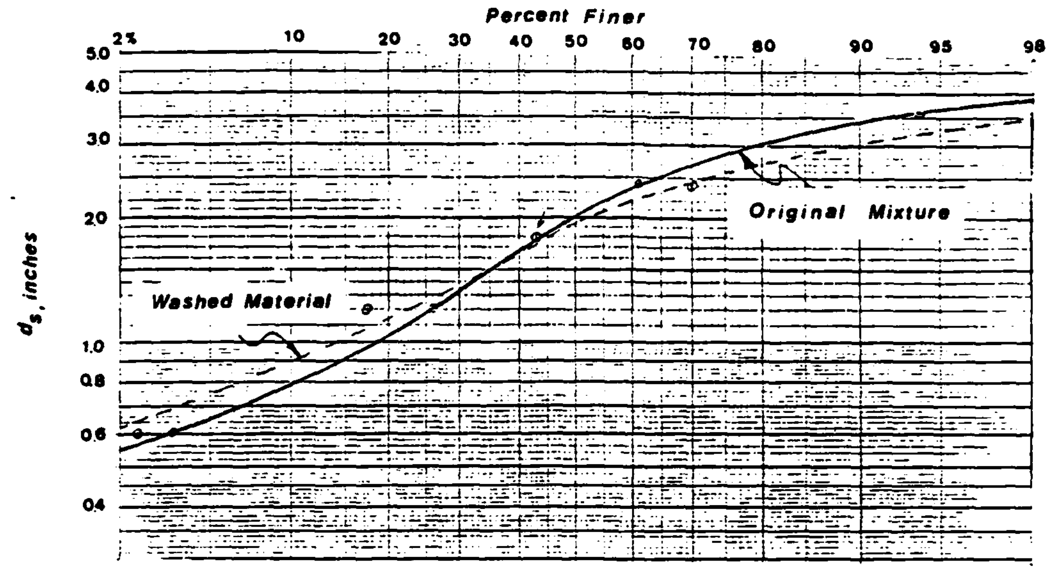
Run No. 14



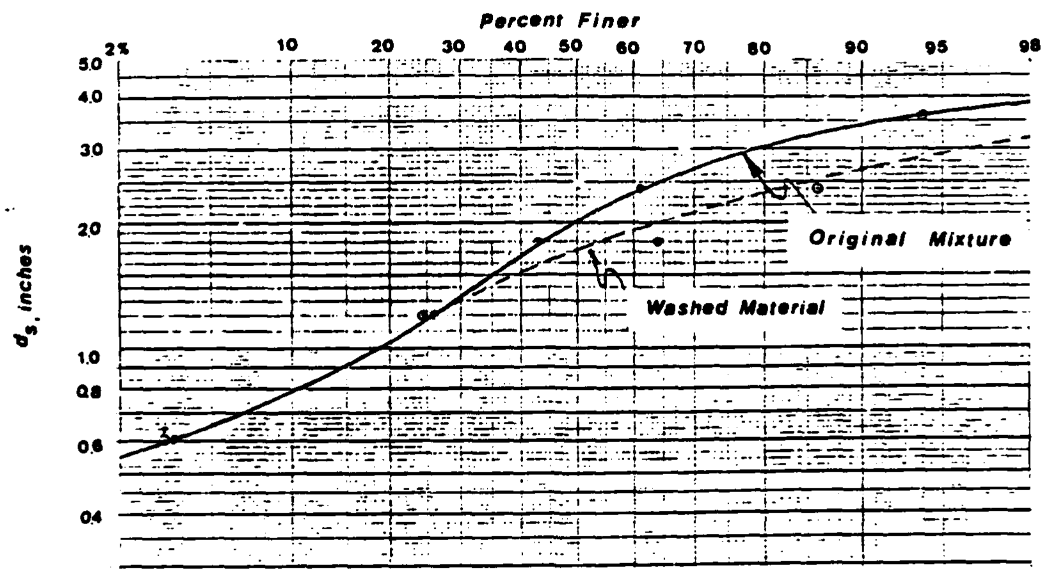
Run No. 17


Percent Finer
2%
5
10
20
30
40
50
60
70
80
90
95
98%
2.0
1.0
.8
.6
.4
.2
.1
.08
.06
d_{50} = .75″
Original Mixture
Washed Material
d_s, inches

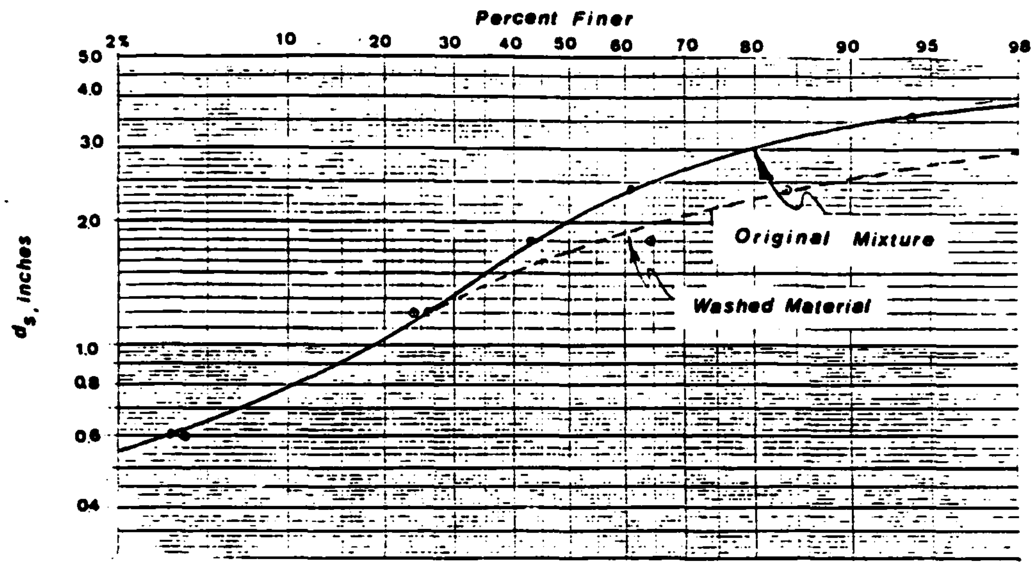
Run No. 18



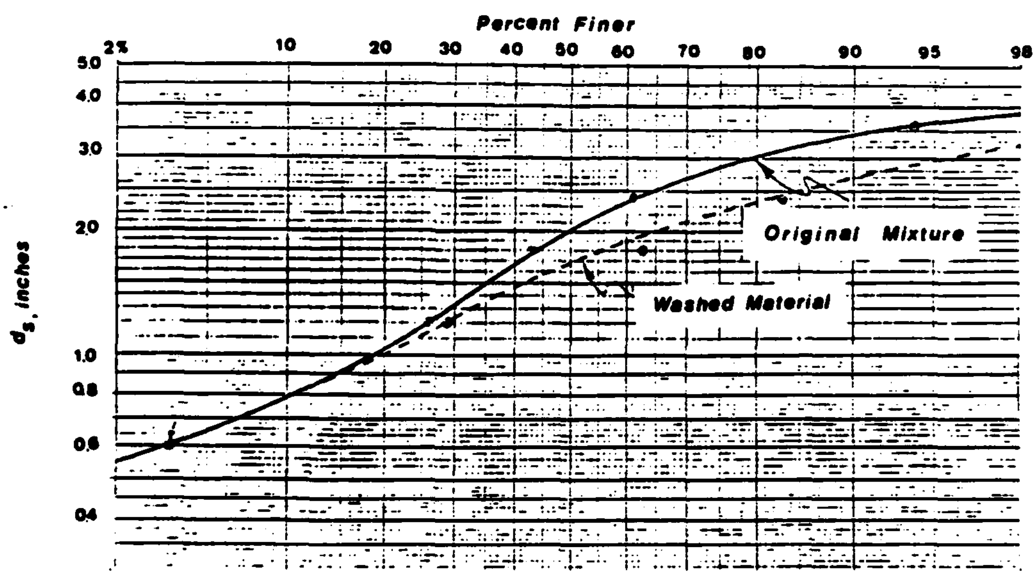
Run No. 7 $d_{50} = 2.0''$



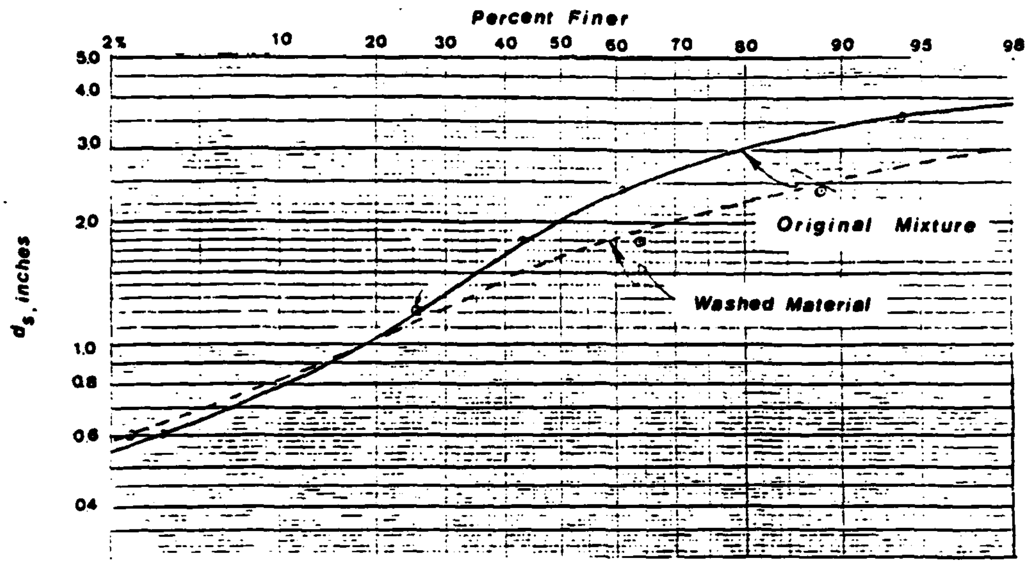
Run No. 8 $d_{50} = 2.0''$



Run No. 9 $d_{50} = 2.0''$



Run No. 12 $d_{50} = 2.0''$



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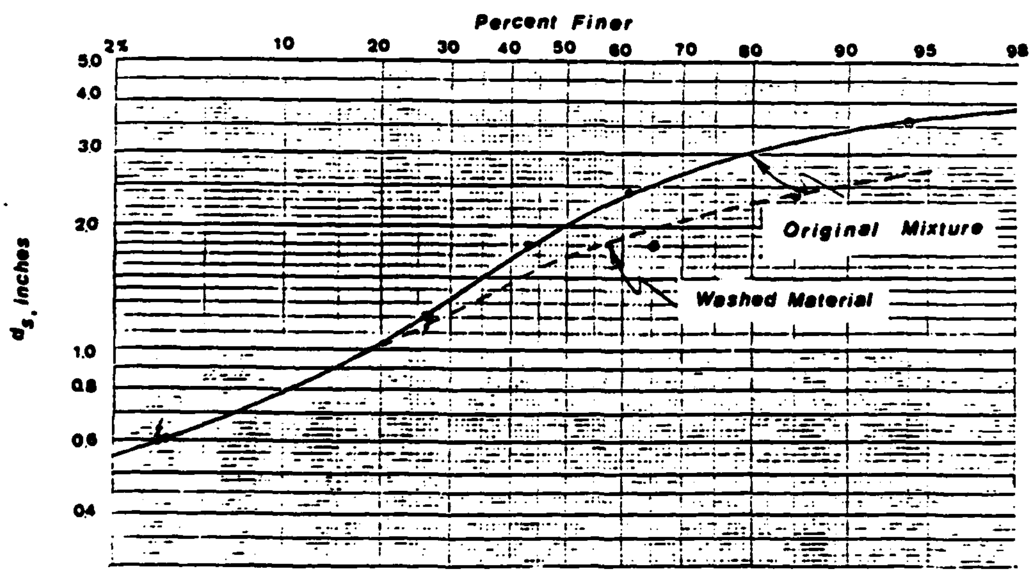
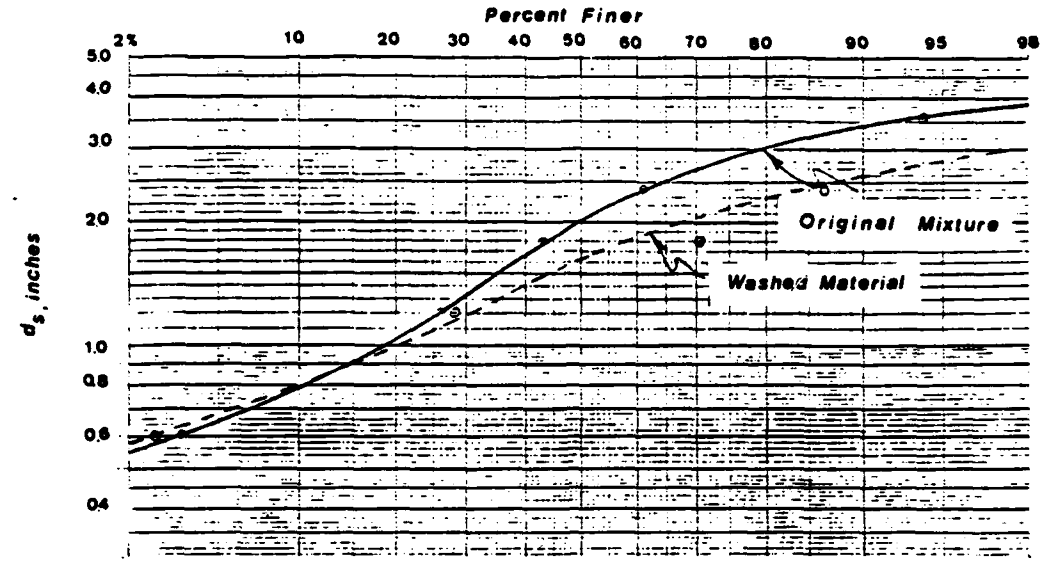
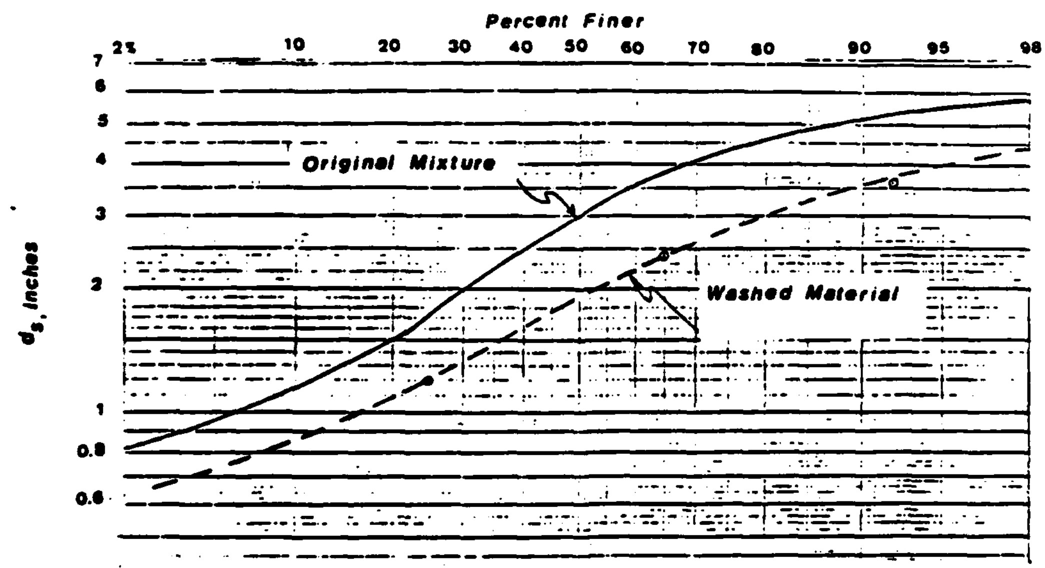


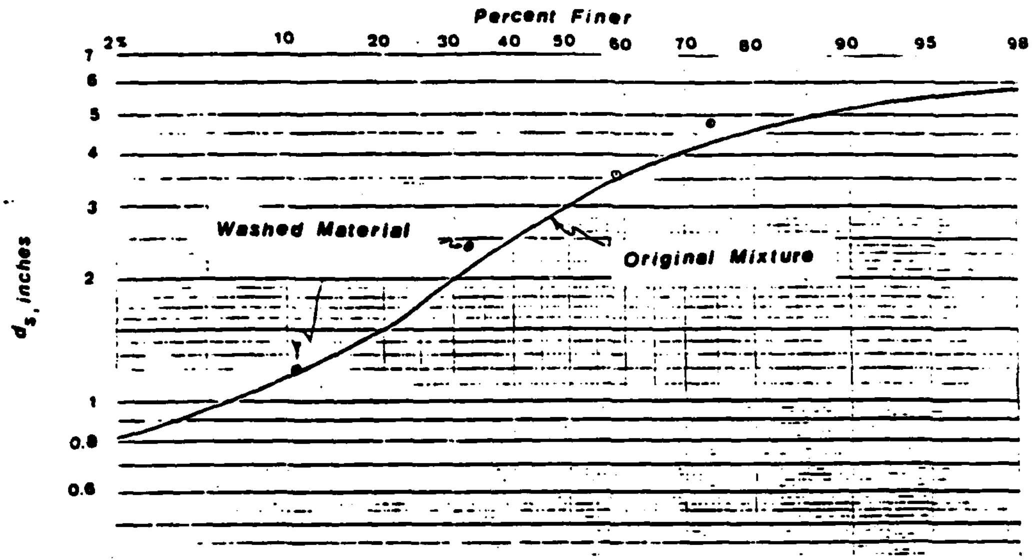
Run No. 17 $d_{50} = 2.0''$



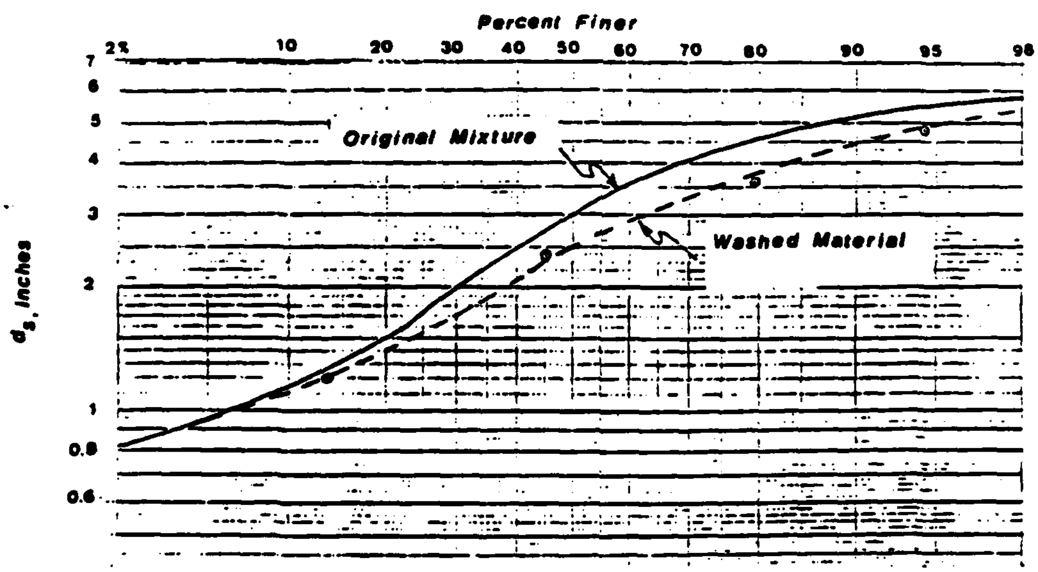
Run No. 18 $d_{50} = 2.0''$



Run No. 4 $d_{50} = 3.0''$



Run No. 5 d_{50}=3.0"



Run No. 9 d_{50}=3.0"

SUPPLEMENTAL STABILITY TESTS OF RIPRAP
IN
FLOOD CONTROL CHANNELS

Draft Report

prepared for

U.S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, Mississippi

Prepared by

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E. V. Richardson

Civil Engineering Department
Engineering Research Center
Colorado State University
Fort Collins, Colorado
December 1983

CER83-84AAF-EVR18

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

FORWARD

This study was performed under a contract Phase II DACW 39-83-C-0045, 30 June 1983, titled "Stability Tests of Riprap in Flood Control Channels" between the U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, and Colorado State University. This report includes the tabulated and mapped data collected during the study, as well as analysis of the major results. The investigation was conducted by Dr. Abbas A. Fiuzat of the Civil Engineering Department, Colorado State University, with supervision and technical advice of Dr. Everett V. Richardson, professor of Civil Engineering, Colorado State University. Mr. Marty Rein, Mr. Howard Clyma and Mr. Ramin Tabib assisted in conducting the study. The study period was July 1983 to September 1983. This report was typed by the Technical Typing staff of the Engineering Research Center, Foothills Campus, Colorado State University.

Chapter 1

INTRODUCTION

1.1 Background

This study was performed as a supplement to earlier studies on the same subject conducted at the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi and Colorado State University (CSU). The content of this report is similar to report number CER81-82AAF-YHC-DBS56 prepared in October 1982 under contract DACW 39-81-C-0054, 21 July 81, by Colorado State University for riprap sizes of 0.75, 2.0 and 3.0 inch median size. Extensive reference will be made to that report, the "1982 report". However, for the sake of completeness, some of the main points will be also explained in "this report".

1.2 Objectives and Conditions of the Study

Tests were conducted to determine the stability of riprap of 0.5 and 1.0 inch median sizes. The stability criteria was resistance to erosion by flow. A constant gradation, specified by WES, was used as shown in Figure 1.1.

Both riprap sizes were tested under four nominal flow rates of 25, 50, 75, and 100 cfs. For each flow rate the tests were conducted in the order of increasing Shields coefficient (Section 2.2) until failure of the riprap and exposure of the underlying filter material. The Shields coefficient, and the corresponding slope, was then reduced and the test repeated for 4 hours to assure stability of the riprap. In case new washout of the riprap was observed, the slope was further

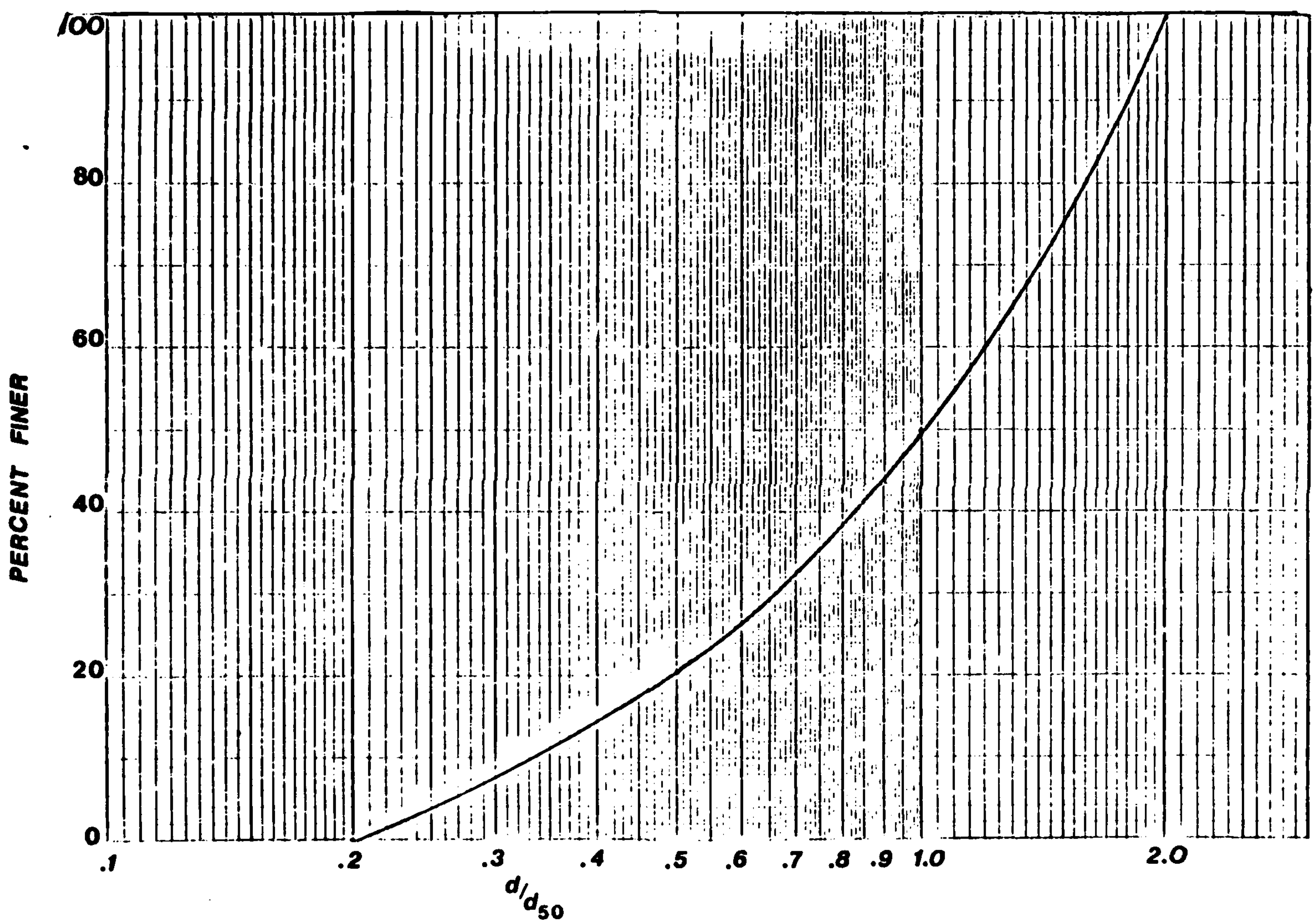


Figure 1.1. Standardized Riprap Gradation

reduced and another prolonged test conducted. The testing procedure and the data collection program are explained in Section 2.5 of this report.

Chapter 2

EXPERIMENTAL PROGRAM

2.1 Experimental Setup

The tests were conducted in the tilting 200-ft-long by 8-ft-wide by 4-ft-deep flume. The experimental setup was the same as explained in the 1982 report. Slightly rougher transition section due to interim use of the flume was the primary difference for the present tests. The tests were therefore conducted under very similar conditions.

The test section was a 50-ft reach of the channel, covered with a layer of riprap underlain by a filter fabric and sand as explained in Section 2.4. This reach was located between stations 99 and 149 of the 200 ft flume. The upstream end of the flume was at station 0. Large 6 to 10-inch rocks cemented to the flume floor between stations 0 and 80 produced a fully developed hydraulically rough boundary flow at the start of the test reach. The boundary layer for the riprap surface was established for the test flow conditions within the first 10 ft or less of the test reach. This fact could be visually observed and can be deduced from Figs. 3.1 to 3.6, presented in Chapter 3. Subsequently, it was decided that for most tests the entrance and exit conditions do not extend much beyond 5 ft from each end. Therefore, the test data with respect to riprap surface failure are reported for the middle 40 ft of the test section.

2.2 Development of the Range of Testing Conditions

As explained in the 1982 report, the Shields coefficient was the primary control for determining the test conditions. The following equations were used:

$$C = \frac{\tau}{(\gamma_s - \gamma_\omega)d_{50}} \tag{2.1}$$

$$\tau = \gamma_\omega DS \tag{2.2}$$

$$\frac{\gamma_s}{\gamma_\omega} = s \tag{2.3}$$

$$Q = \frac{1.49}{n} WD^{5/3} S^{1/2} \tag{2.4}$$

$$n = \frac{d_{90}^{\;1/6}}{26} \tag{2.5}$$

where C = Shields coefficient; τ = boundary shear stress; γ_s and γ_ω = solid and water unit weights respectively; d_{50} = median size of riprap; D = flow depth; S = uniform flow bed or water surface slope; s = specific gravity; Q = flow rate; n = Manning's roughness factor; W = flume width; and d_{90} = the size of which 90 percent of material is finer. Note that in Eqs. 2.2 and 2.4 the depth has been approximated for the hydraulic radius. These equations do not have to be exact since they are used only for developing the test conditions. Using Eqs. 2.1, 2.2 and 2.3, it can be found that

$$C = \frac{DS}{(s-1)d_{50}} \tag{2.6}$$

from which

$$D = \frac{C(s-1)d_{50}}{S} \tag{2.7}$$

Substituting for D in Eq. 2.4 and solving for the slope,

$$S = \left[\frac{1.49W}{nQ}\right]^{6/7} \left[C(s-1)d_{50}\right]^{10/7} \tag{2.8}$$

The flume width is 8 ft and the locally available riprap has a specific gravity of 2.65. Substituting these values in Eq. 2.8 yields

$$S = 17.07(nQ)^{-6/7} \, (Cd_{50})^{10/7} \tag{2.9}$$

The riprap size and flow rate have been specified for each test. The corresponding roughness factor can be found from Eq. 2.5. Thus, for each desired value of the Shields coefficient C the necessary flume slope can be determined from Eq. 2.9; the expected flow depth can be found from Eq. 2.7; and the flow velocity V can be found from the continuity equation

$$V = \frac{Q}{WD} \tag{2.10}$$

The range of testing conditions determined on this basis are shown in Tables 2.1 and 2.2. As mentioned in the 1982 report, the values of the roughness factor have been increased by 20 percent from those indicated by Eq. 2.5 to obtain the correct bed roughness.

2.3 Mixing Procedures and Preparation of Riprap Material

The riprap was to be laid at a depth of twice its median diameter. Knowing the dimensions of the test section and having the depth of riprap layer, the total volume of the needed material was readily determined. Given the gradation of Figure 1.1, the materials of various size ranges were mixed to obtain the required gradation. The maximum rock size to be used was $2d_{50}$ as Figure 1.1 shows. The locally available materials had the sizes shown in Table 2.3. Thus, for the riprap of 0.5 in. median diameter, material from Groups I and II were

Table 2.1. The Range of Testing Conditions for the 0.5 inch-Riprap.

C	Q = 25 cfs			Q = 50 cfs			Q = 75 cfs			Q = 100 cfs		
	S	D (ft)	V (fps)	S	D (ft)	V (fps)	S	D (ft)	V (fps)	S	D (ft)	V (fps)
0.025	0.00143	1.204	2.59	0.00079	2.182	2.86	0.00056	3.088	3.04	0.00044	3.952	3.16
0.030	0.00185	1.114	2.81	0.00102	2.018	3.10	0.00072	2.856	3.28	0.00056	3.655	3.42
0.035	0.00231	1.043	3.00	0.00128	1.889	3.31	0.00090	2.673	3.51	0.00070	3.421	3.65
0.040	0.00280	0.985	3.17	0.00154	1.784	3.50	0.00109	2.525	3.71	0.00085	3.231	3.87
0.045	0.00331	0.936	3.34	0.00183	1.696	3.69	0.00129	2.400	3.91	0.00101	3.072	4.07
0.050	0.00384	0.895	3.49	0.00212	1.621	3.86	0.00150	2.294	4.09	0.00117	2.936	4.26

d_{50} = 0.50 in = 0.0417 ft;
d_{90} = 0.880 in = 0.0224 m;
n = 0.0245.

Table 2.2. The Range of Testing Conditions for the 1-inch Riprap

C	Q = 25 cfs			Q = 50 cfs			Q = 75 cfs			Q = 100 cfs		
	S	D ft	V fps	S	D ft	V fps	S	D ft	V fps	S	D ft	V fps
0.025	0.00348	0.988	3.16	0.00192	1.790	3.49	0.00136	2.535	3.70	0.00106	3.243	3.85
0.030	0.00451	0.914	3.42	0.00249	1.656	3.77	0.00176	2.344	4.00	0.00137	3.000	4.17
0.035	0.00562	0.856	3.65	0.00310	1.550	4.03	0.00219	2.194	4.27	0.00171	2.808	4.45
0.040	0.00680	0.808	3.87	0.00376	1.464	4.27	0.00265	2.072	4.52	0.00207	2.652	4.71
0.045	0.00805	0.768	4.07	0.00444	1.392	4.49	0.00314	1.970	4.76	0.00245	2.521	4.96
0.050	0.00936	0.734	4.26	0.00517	1.330	4.70	0.00365	1.883	4.98	0.00285	2.410	5.19

d_{50} = 1.0 in. = 0.0833 ft;

d_{90} = 1.76 in = 0.0447 m;

n = 0.0275.

mixed at equal quantities. For the 1.0 in. median size, material from all four groups were mixed to obtain the desired gradation. It should be noted that for both mixes there was perhaps more fine material than Figure 1.1 indicates since Group I has no lower limit. However, for all practical purposes, material finer than 0.2 d_{50} was considered to play an insignificant role in stability of riprap and hence it was decided not to sieve or separate the very fine material.

Table 2.3. Ranges of Locally Available Riprap Material

Group	Size Range
I	Less than 0.5 in.
II	0.5 to 1.0 in.
III	1.0 to 1.5 in.
IV	1.5 to 2.0 in.

After preparing each riprap mixture a size analysis using the standard sieve method was conducted. The results are shown in Table 2.4 and Figure 2.1. The data of the previous riprap mixes are included in both Fig. 2.1 and Table 2.4 for comparison.

Table 2.4. Gradation of the Riprap Material

Design d_{50} in.	Design Gradation		Actual d_{50} in.	Actual Gradation	
	d_{84}/d_{50}	d_{50}/d_{16}		d_{84}/d_{50}	d_{50}/d_{16}
3/4	1.65	2.35	3/4	1.49	3.23
2.0	1.65	2.35	1.87	1.49	1.85
3.0	1.65	2.35	3.0	1.60	2.33
1/2	1.65	2.35	0.50	1.34	1.61
1.0	1.65	2.35	0.98	1.62	2.70

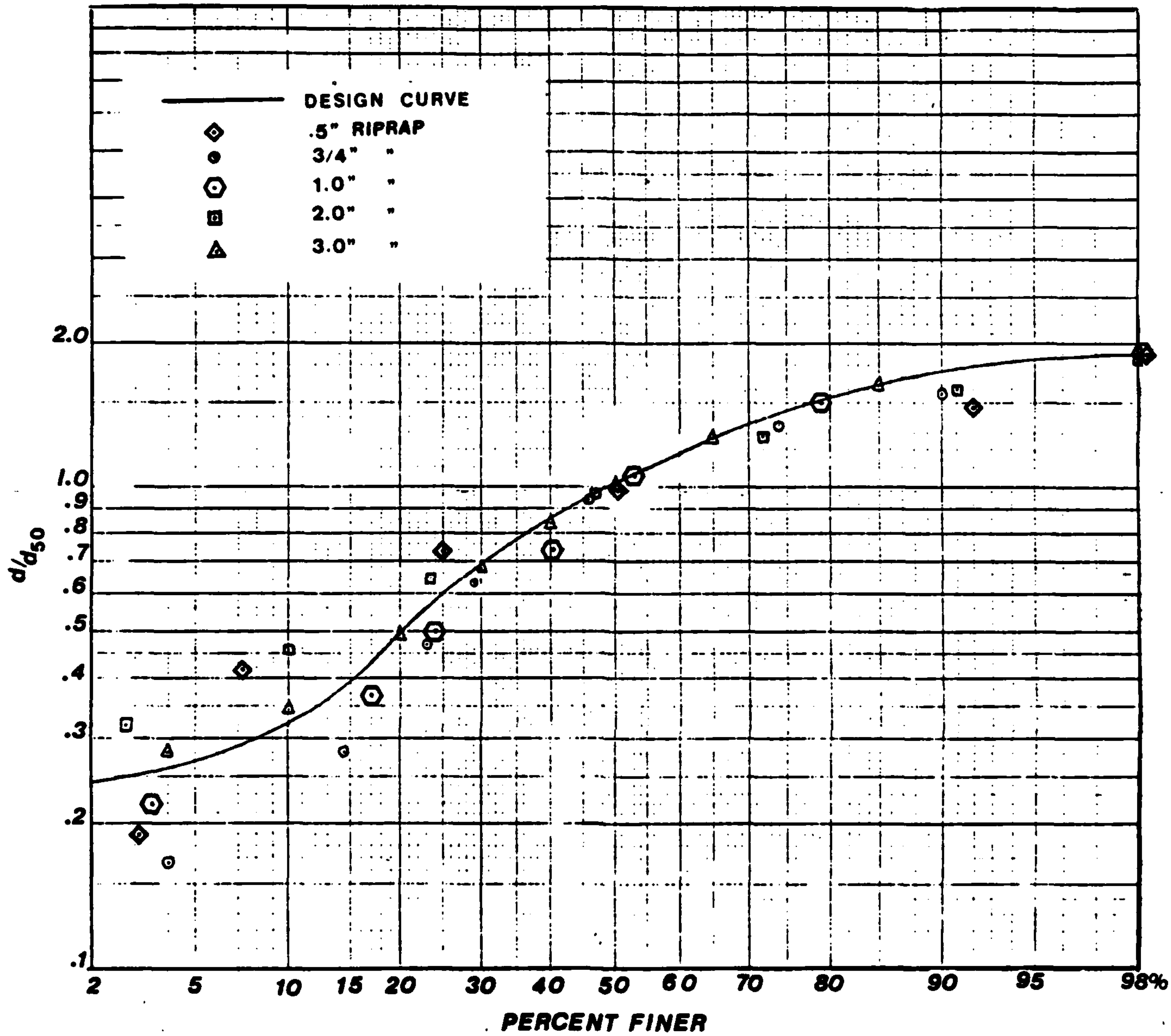


Figure 2.1. Standardized Size Distribution of the Riprap Mixtures

2.4 Construction of the Riprap Surface

The riprap bed was prepared by placing a 3-inch layer of fine sand on the flume floor and covering it with a layer of Typar filter paper. The filter paper was secured to the flume by a narrow wooden frame underneath and plaster laths on the outside. The riprap was dumped on the filter paper at a thickness of two median diameters without further tampering. However, this surface was occasionally retouched when water had washed one spot and piled the material at an adjacent location on the test surface. The transition section was not altered through the course of this study.

2.5 Testing Procedure and Data Collection Program

The order of testing was arranged from the smaller to the larger size of riprap and from the smallest to the largest flow rate for each size. After placing each riprap size, a suitable value of the Shields coefficient, C, was chosen from Tables 2.1 and 2.2 and the flume slope was adjusted accordingly. The value of C was usually chosen small enough so that no washout would be observed in the first run. The desired discharge was then routed. The starting depth of flow was maintained at a value larger than uniform flow depth (Tables 2.1, 2.2). By gradually opening the tailwater gate and taking depth measurements, the depth was reduced until uniform flow occurred on the test section. This procedure eliminated the possibility of washing the riprap due to nonuniform flow conditions.

The test was continued for 1.5 to 2 hours after establishing uniform flow. During this time flow depths and velocities were measured at the midpoint of the flume cross section at 3 stations: 10 ft, 25 ft, and 40 ft from the beginning of the test section.

Velocities were measured by an Ott current meter at two points in the vertical: 0.2 D and 0.8 D from the water surface. These data were used to find the average velocity and average depth of flow at the test section.

The discharge was measured by calibrated orifices installed in the pipes conveying water from the pumps to the head box. The differential head across the orifice was measured by water or mercury manometers depending on the discharge. The manometer readings were checked several times during each test to make sure a constant discharge was being routed. However, some variation in discharge readings could exist due to fluctuating manometers. The water temperature was also measured and recorded.

After each test, if no washout of the riprap was observed, the flume slope was increased to obtain a higher value of the Shields coefficient, according to Tables 2.1 and 2.2. Similar procedures were followed until the conditions produced riprap failure. At this time the washed riprap which was collected by downstream traps was analyzed for size distribution, and the locations and sizes of the washout areas on the riprap surface were mapped and recorded. The washed out riprap surface was then repaired by placing new riprap, the flume slope was reduced to one step less than the failure slope and the discharge was routed again under uniform conditions. The test under these conditions was carried out for 4 hours to check riprap stability.

Data for these tests were collected more extensively at stations 10 ft, 25 ft, and 40 ft from the beginning of the test section. At each station, 3 verticals were used for measuring the depth and velocity, namely at 0.17 W, 0.50 W and 0.83 W across the section.

Velocities were measured on each vertical at 5 points, namely, at 0.1, 0.3, 0.5, 0.7 and 0.9D from the water surface. Thus, 9 depths and 45 velocities were measured. Discharge and temperature were also measured and recorded as before. Upon stopping the test and draining the flume, if riprap failure had again occurred under the test conditions, the slope was reduced another step and the four hour test and extensive data collection procedures were followed. If riprap failure was not observed, these conditions were assumed to be the incipient motion conditions for the riprap under test and for the discharge being routed. To compare the type of rock washed out, one determination of specific gravity of the original mix and one of the washed rocks were performed.

2.6 Summary of the Test Conditions

Based on the testing conditions and procedures, a total of 48 acceptable runs was conducted. The summary of the test conditions is presented in Table 2.5. If during a test insufficient control of flow and nonuniform flow conditions were observed, the results of the test were discarded.

Table 2.5. Summary of the Test Conditions.

Riprap Size (in.)	Orifice Discharge (cfs)	Run Number	Flume Slope	Area* Washed (sq. ft)	Water Temperature °F
0.50	25	1	0.00143	--	64
		2	0.00185	--	70
		3	0.00231	--	70
		4	0.00280	--	65
		5	0.00331	0.76	70
		6	0.00331	36.86	73
		7	0.00280	5.70	75
		8	0.00231	6.08	70
	50	9	0.00102	1.14	70
		10	0.00128	3.04	75
		11	0.00154	20.52	72
		12	0.00102	1.00	74
	75	13	0.00072	0.70	74
		14	0.00090	5.00	74
		15	0.00072	11.78	74
		16	0.00056	--	74
	100	17	0.00056	5.70	74
1.0	25	1	0.00348	--	73
		2	0.00451	--	74
		3	0.00451	--	74
		4	0.00562	4.30	70
		5	0.00451	0.07	73
	50	6	0.00249	0.50	70
		7	0.00310	3.80	71
		8	0.00249	0.25	70
	75	9	0.00176	5.25	72
		10	0.00176	0.25	70
		11	0.00219	0.25	70
		12	0.00265	5.10	-
		13	0.00219	9.60	60
		14	0.00176	--	78
	100	15	0.00106	1.50	77

*Washed areas are reported from 5 ft to 45 ft of the test section only.

Chapter 3

DATA ANALYSIS

In order for comparisons to be possible, the data analysis in this report is similar to the 1982 report. Average depths and velocities were found by averaging the entire data for each run, for reasons given in the 1982 report. The complete set of collected data are attached in the appendix to this report.

3.1 Basic Equations and Method of Analysis

Derivations of the basic equations used for analyzing the data are given in the 1982 report. Following are the final equations used for analyzing the data. For derivations, reference should be made to the 1982 report.

$$n_b = \left[\frac{n^{3/2}P - (0.012)^{3/2}\ (2D)}{8}\right]^{2/3} \tag{3.1}$$

$$n = \frac{1.49}{V}\left(\frac{8D}{8 + 2D}\right)^{2/3} S^{1/2} \tag{3.2}$$

$$P = 8 + 2D \tag{3.3}$$

where n_b = Manning's roughness factor for the bed; n = overall Manning's roughness factor, found from Eq. 3.2; P = overall wetted perimeter, found from Eq. 3.3; D = flow depth; V = flow velocity; and S = channel slope. The above equations were used to determine the Manning's roughness factor for the riprap surface. A second set of equations used were the following:

$$C = \frac{R_b S}{(s-1)\ d_{50}} \tag{3.4}$$

$$\frac{V^2}{8} = \frac{g\ S\ R}{f} = \frac{g\ S\ R_b}{f_b} \tag{3.5}$$

$$f_b = f + \frac{D}{4}\ (f - f_w) \tag{3.6}$$

$$\frac{R_w}{f_w} = \frac{R}{f} \tag{3.7}$$

Where C = Shields coefficient; R_b = wetted perimeter for bed; s = specific gravity of riprap material; d_{50} = median size of riprap; g = acceleration of gravity; R = channel wetted perimeter; f, f_b and f_w = Darcy Weisbach friction factor for the flume, bed and wall respectively; and R and R_w = Reynolds number for channel and wall respectively. Other variables are as defined before. Equation 3.7 is solved by the method given in reference No. 6, p. 153, to find f_w; f_b is then found from Eq. 3.6; R_b is solved for from Eq. 3.5 and finally the Shields coefficient is found by Eq. 3.4. It was explained in section 2.5 that after riprap washout the slope was reduced and the test repeated to find the condition of incipient riprap motion. The value of Shields coefficient for this condition found by Eq. 3.4 is called the bed critical Shields coefficient and is denoted by C_{cb}.

An alternative method of determination of the critical Shields coefficient is to plot the washed area versus the Shields coefficient. Extending the plots to where zero washed area is obtained will give the critical Shields coefficient, denoted by C_c.

A third method of finding the critical Shields coefficient is the analysis of WES. This value is shown by C_{cw}, using the equation

$$\frac{d_{50}}{D} = \frac{26.06\ K^3}{C_{cw}^{\ 3/2}}\ F^3 \tag{3.8}$$

$$F = \frac{V}{\sqrt{gD}} \tag{3.9}$$

where K has been defined in Eq. 2.5 to have a value of $\frac{1}{26}$, but may assume other values, and F is the Froude number.

Tables 3.1 and 3.2 show the results of calculations for the two riprap sizes. These results will be used in subsequent analyses.

3.2 Representative Velocity Distributions at the Incipient Motion Conditions

After each riprap failure the slope was reduced and a prolonged run performed to find the stable conditions for the specific riprap size and discharge under study (Section 2.5). These conditions are referred to hereafter as the incipient motion conditions. Representative velocity distributions for these conditions have been plotted and presented in Figures 3.1 through 3.6, in which x refers to distance along the test section and y refers to distance across the section.

3.3 Determination of Incipient Motion Conditions

The procedure for determining the incipient motion conditions using the washed areas has been briefly explained in Section 3.1. Figures 3.7 and 3.8 show the plots of washed areas vs. Shields coefficient. There are no plots for the 100 cfs flow because at the Shields coefficient of 0.025 riprap surface wash was observed. Reducing the slope to a smaller value would result in larger flow depths. However, in both cases of riprap the flow freeboard was no more than 1.5 inches and testing under any milder slopes could not physically be done. The result is consistent with the 1982 report that C_c does not seem to indicate any correlation with discharge or riprap size, as shown in Figure 3.9.

Table 3.1. Calculations for the 0.5-Inch Riprap

Run No.	Nominal discharge Q cfs	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number $F^{(1)}$	Manning's roughness factor $n_b^{(2)}$	Shields coefficient $C^{(3)}$	Area washed ft^2	Boundary Reynolds number $R_*^{(4)}$
1	25	0.00143	1.763	1.434	0.26	0.040	0.029	--	1071
2	25	0.00185	2.269	1.335	0.35	0.034	0.036	--	1175
3	25	0.00231	2.391	1.277	0.37	0.035	0.043	--	1284
4	25	0.00280	2.779	1.106	0.47	0.030	0.045	--	1316
5	25	0.00331	2.940	1.021	0.51	0.029	0.049	0.76	1374
6	25	0.00331	3.147	0.922	0.58	0.025	0.044	36.86	1306
7	25	0.00280	3.212	1.201	0.52	0.027	0.049	5.70	1371
8††	25	0.00231	3.155	1.030	0.55	0.022	0.035	6.08	1153
9	50	0.00102	3.022	1.961	0.38	0.024	0.029	1.14	1057
10	50	0.00128	3.135	1.894	0.40	0.025	0.035	3.04	1164
11†	50	0.00154	3.175	1.805	0.42	0.027	0.040	20.52	1247
12††	50	0.00102	3.085	2.047	0.38	0.024	0.030	1.00	1080
13	75	0.00072	3.410	2.958	0.35	0.023	0.031	0.70	1091
14	75	0.00090	3.610	2.724	0.39	0.023	0.036	5.00	1171
15	75	0.00072	3.372	2.855	0.35	0.023	0.030	11.78	1072
16††	75	0.00056	3.154	3.02[illegible]	0.32	0.023	0.025	--	973
17	100	0.00056	3.469	3.550	0.32	0.023	0.029	5.70	1054

(1) Equation 3.9

(2) Equation 3.1

(3) Equation 2.6

(4) $$R_* = \frac{V_* d_{50}}{\nu} = \frac{\sqrt{gDS}\ d_{50}}{1\text{x}10^{-5}}$$

† Not to be considered for data plotting.

†† Incipient motion tests.

Table 3.2. Calculations for the 1.0-Inch Riprap

Run No.	Nominal discharge Q cfs	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number $F^{(1)}$	Manning's roughness factor $n_b^{(2)}$	Shields coefficient $C^{(3)}$	Area washed ft^2	Boundary Reynolds number $R_*^{(4)}$
1	25	0.00348	2.952	1.047	0.51	0.030	0.026	0.00	2854
2†	25	0.00451	2.648	0.967	0.47	0.036	0.032	--	3123
3	25	0.00451	3.027	0.978	0.54	0.032	0.032	--	3141
4	25	0.00562	3.427	0.848	0.66	0.029	0.035	4.30	3264
5††	25	0.00451	3.373	0.926	0.62	0.028	0.031	0.07	3056
6	50	0.00249	3.568	1.689	0.48	0.029	0.031	0.50	3067
7	50	0.00310	3.653	1.581	0.51	0.030	0.036	3.80	3310
8††	50	0.00249	3.880	1.660	0.53	0.026	0.030	0.25	3040
9†	75	0.00176	4.359	2.305	0.51	0.024	0.030	5.25	3012
10	75	0.00176	3.922	2.561	0.43	0.029	0.033	0.25	3175
11	75	0.00219	4.119	2.416	0.47	0.030	0.039	0.25	3440
12	75	0.00265	4.360	2.284	0.51	0.030	0.044	5.10	3679
13	75	0.00219	4.056	2.478	0.45	0.031	0.040	9.60	3484
14††	75	0.00176	3.796	2.442	0.43	0.029	0.031	0.00	3100
15	100	0.00106	3.710	3.310	0.36	0.025	0.026	1.50	2801

(1) Equation 3.9

(2) Equation 3.1

(3) Equation 2.6

(4) $$R_* = \frac{V_* d_{50}}{\nu} = \frac{\sqrt{gDS}\ d_{50}}{1\times10^{-5}}$$

†Not to be considered for data plotting.

††Incipient motion tests.

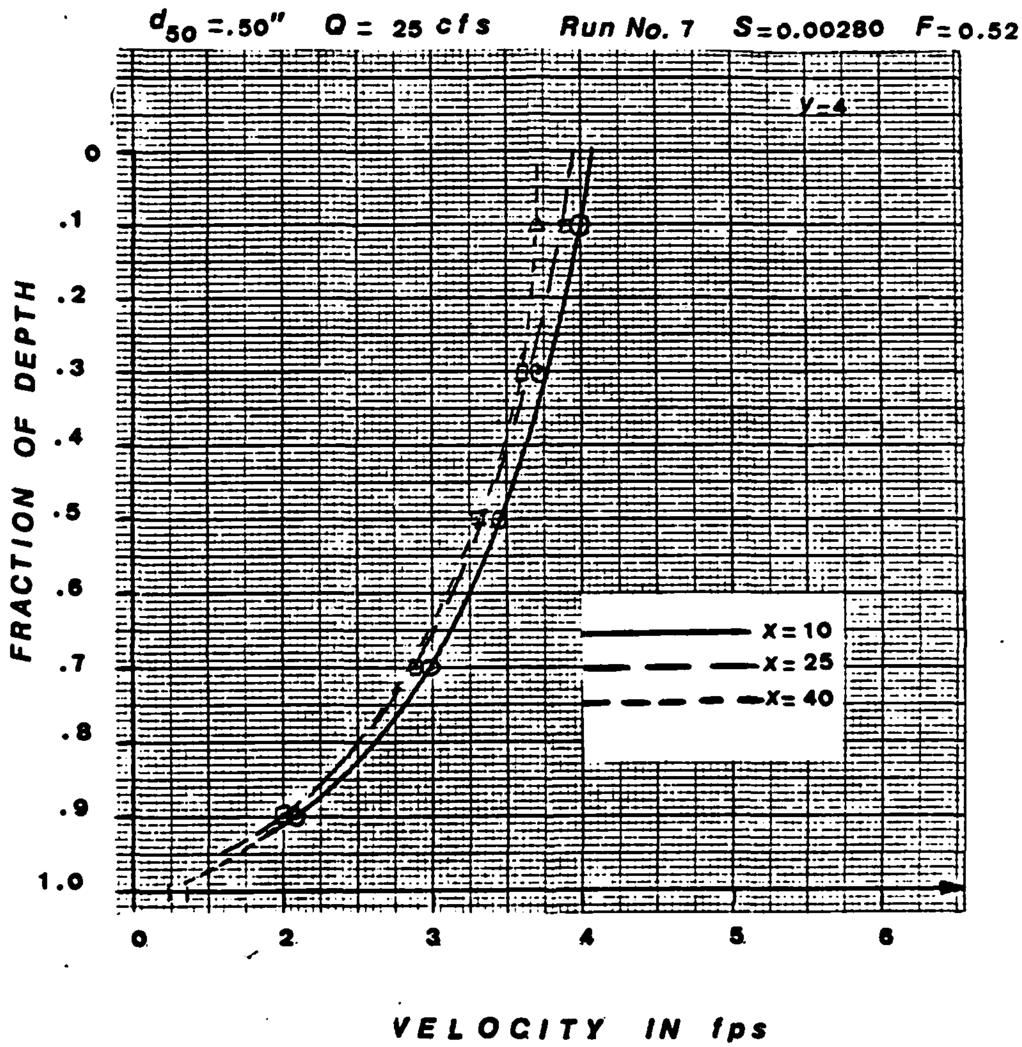


Figure 3.1. Velocity Profile for the 0.5 inch riprap, Run No. 7

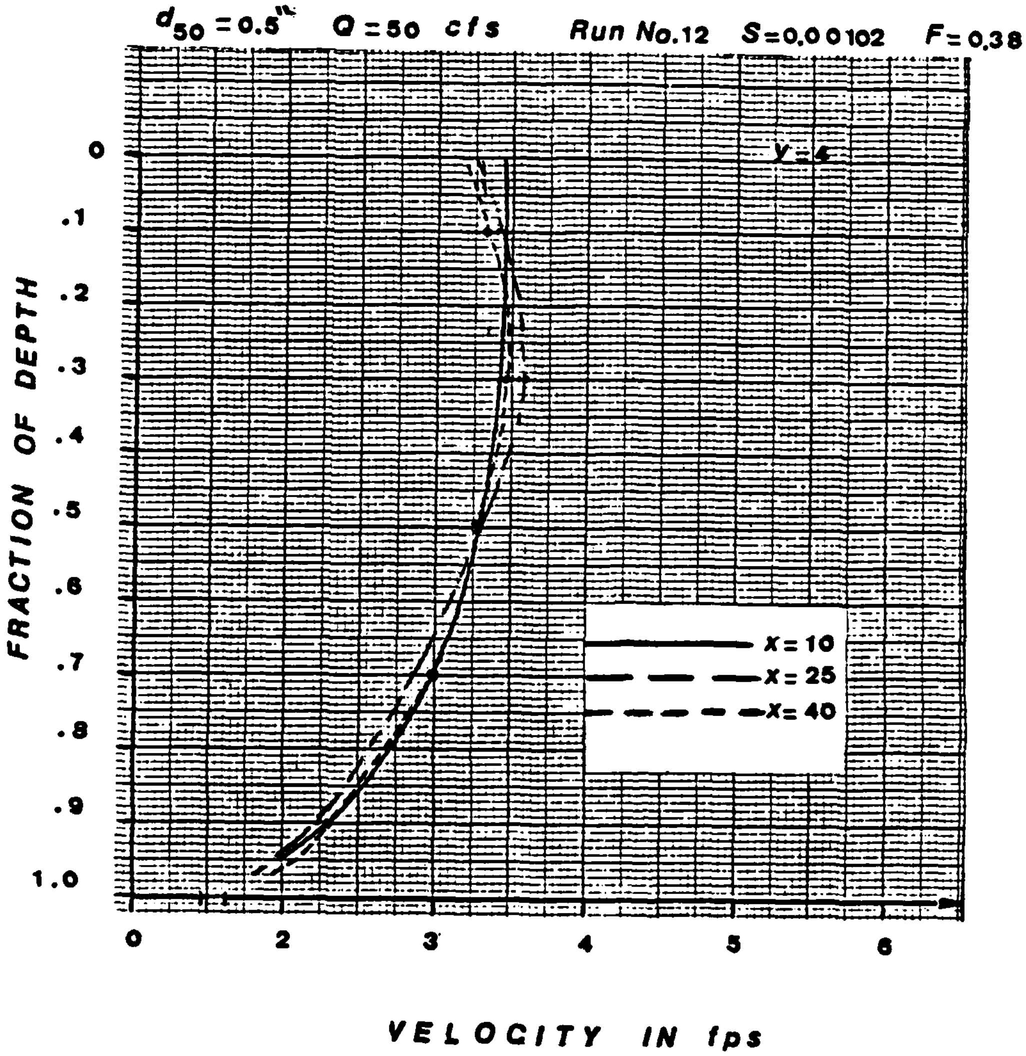


Figure 3.2. Velocity Profile for the 0.5 inch Riprap, Run No. 12

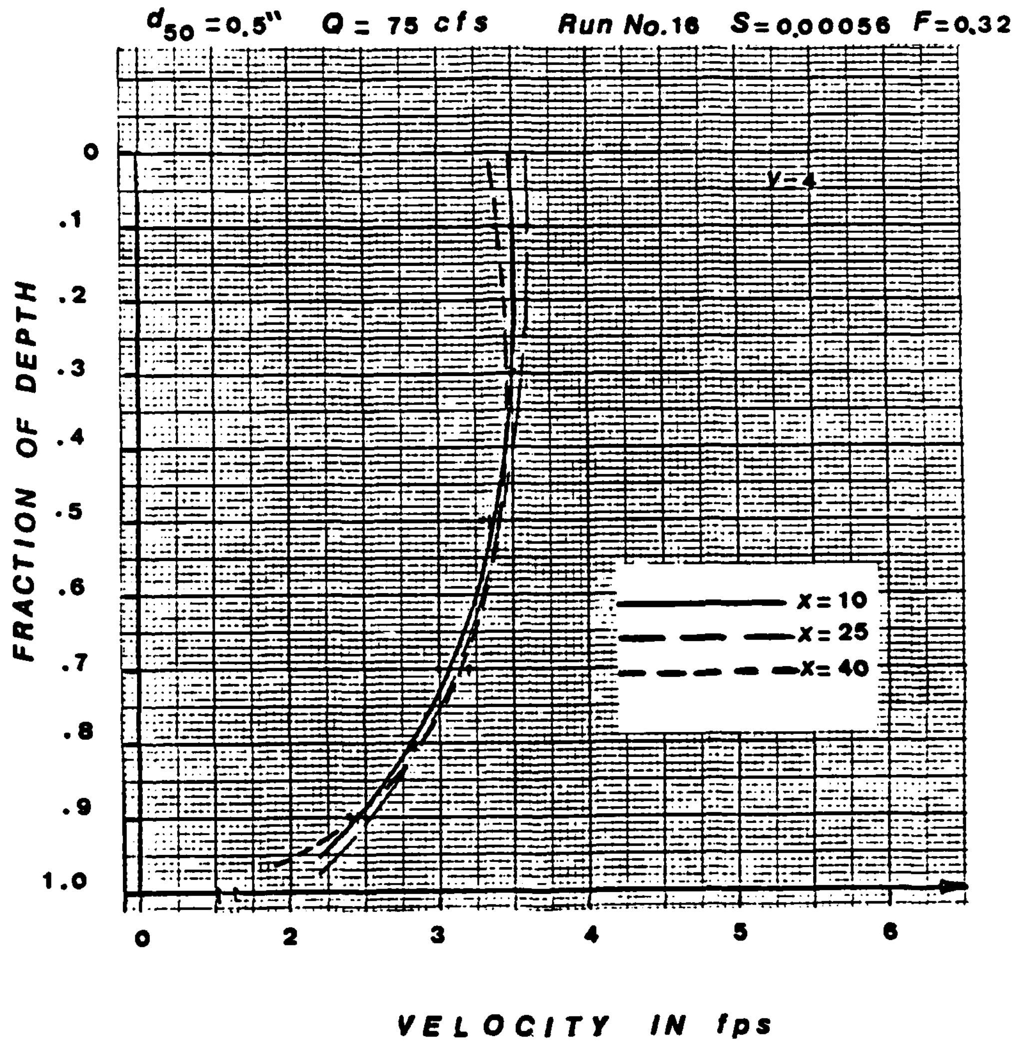


Figure 3.3. Velocity Profile for the 0.5 inch Riprap, Run No. 16

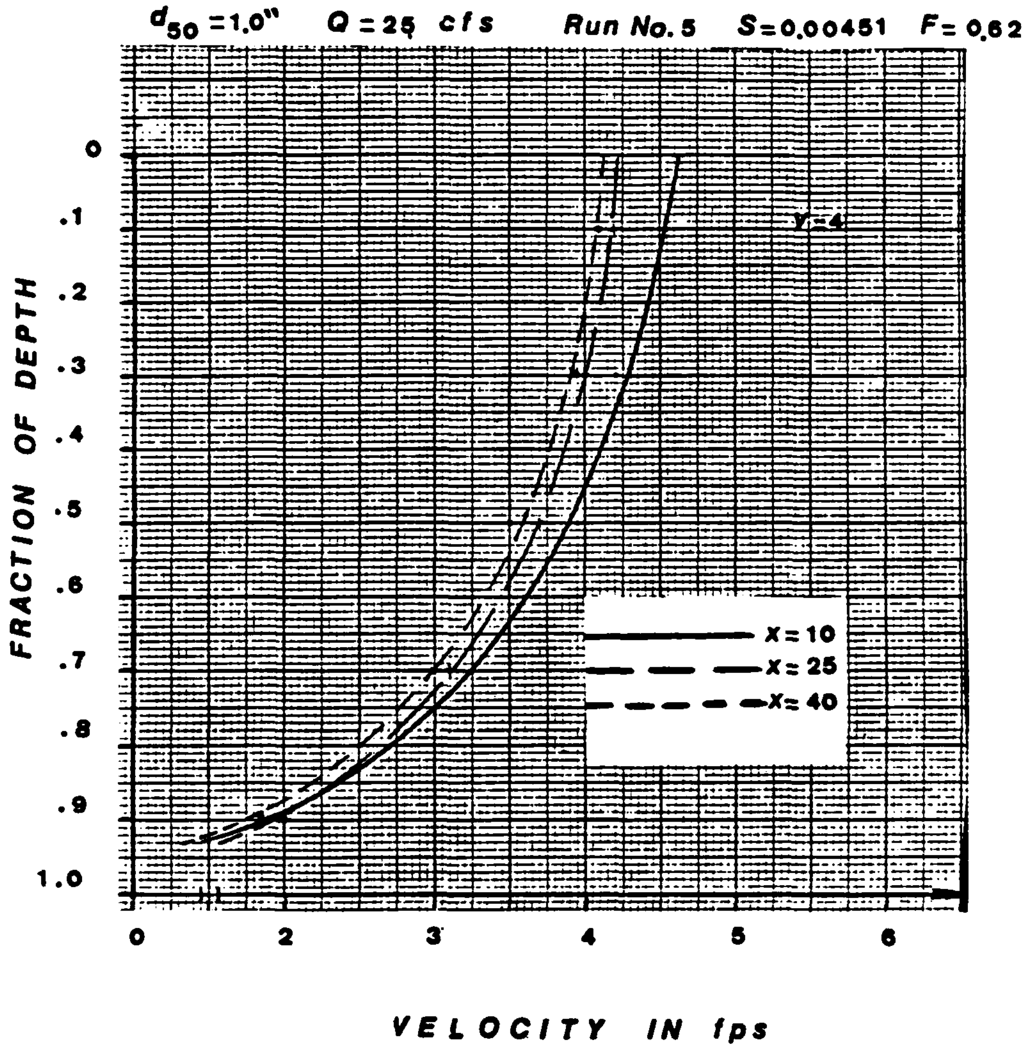


Figure 3.4. Velocity Profile for the 1 inch Riprap, Run No. 5

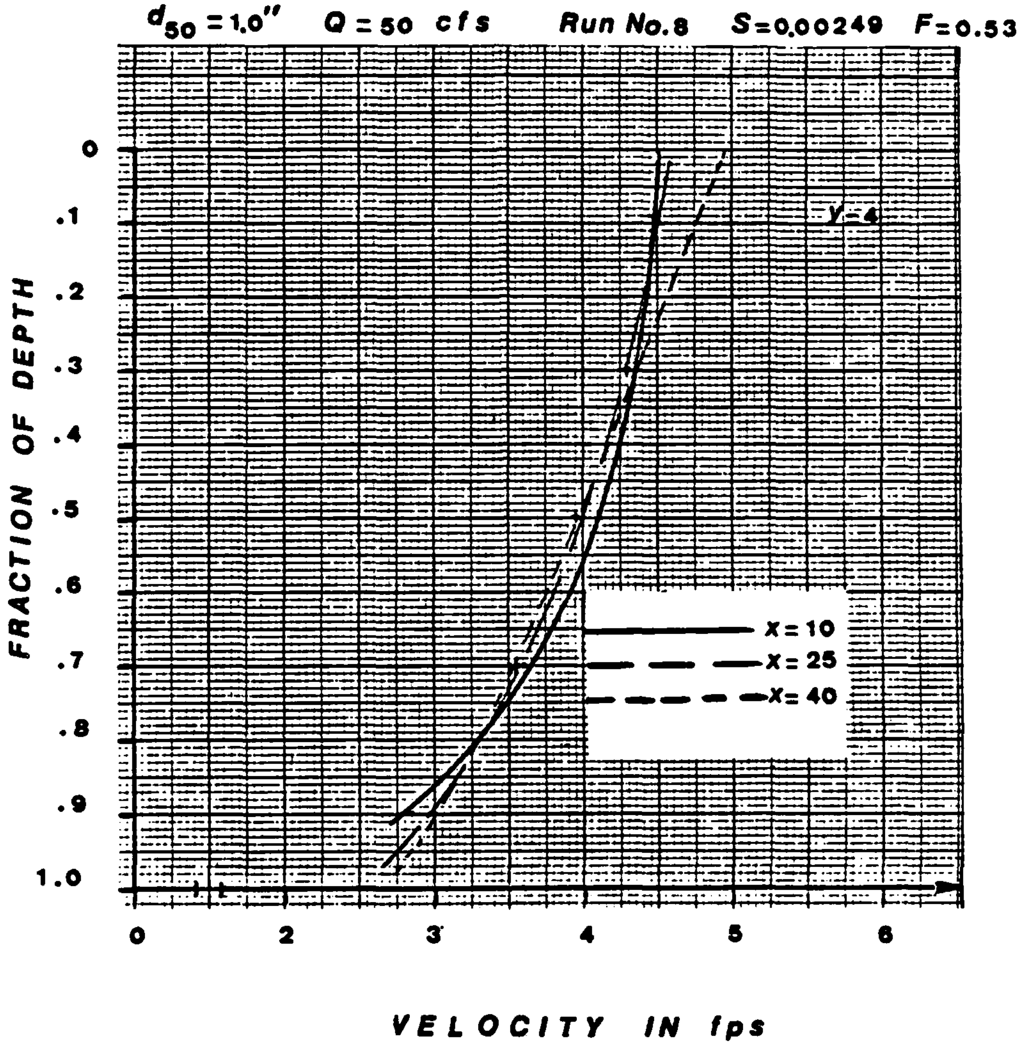


Figure 3.5. Velocity Profile for the 1 inch Riprap, Run No. 8

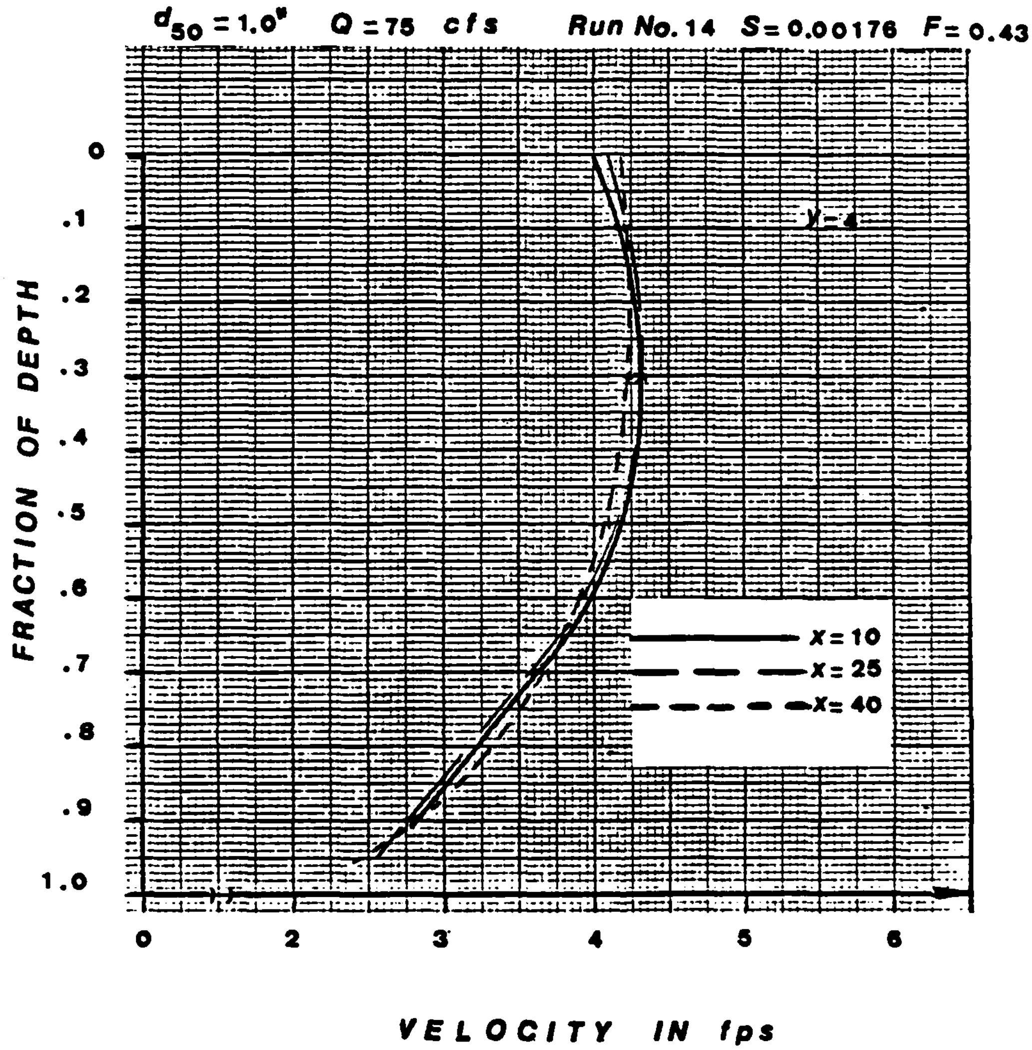


Figure 3.6. Velocity Profile for the 1 inch Riprap, Run No. 14

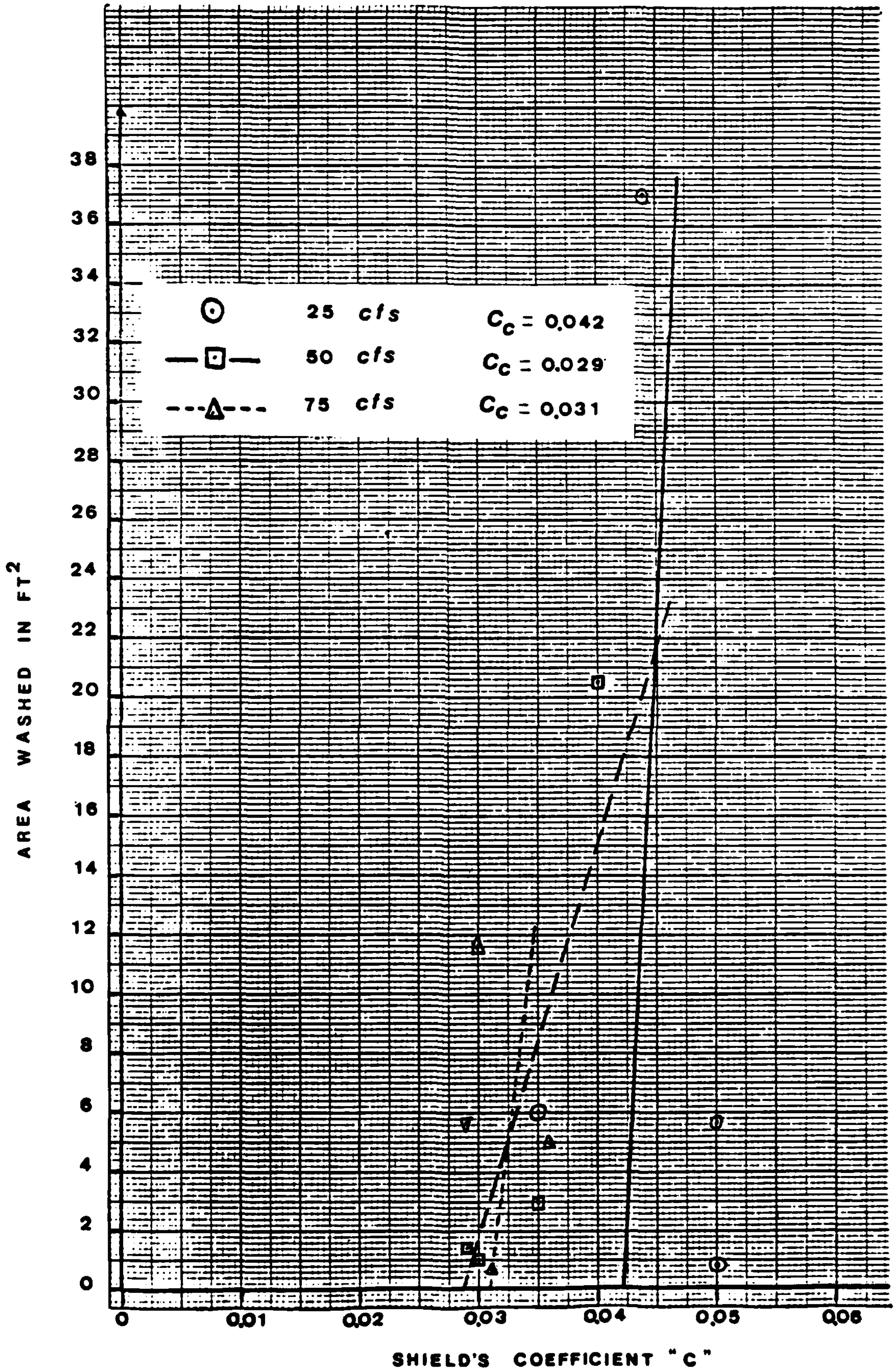


Figure 3.7. Determination of the Critical Shields Coefficient from Washed Areas for 0.5 inch Riprap.

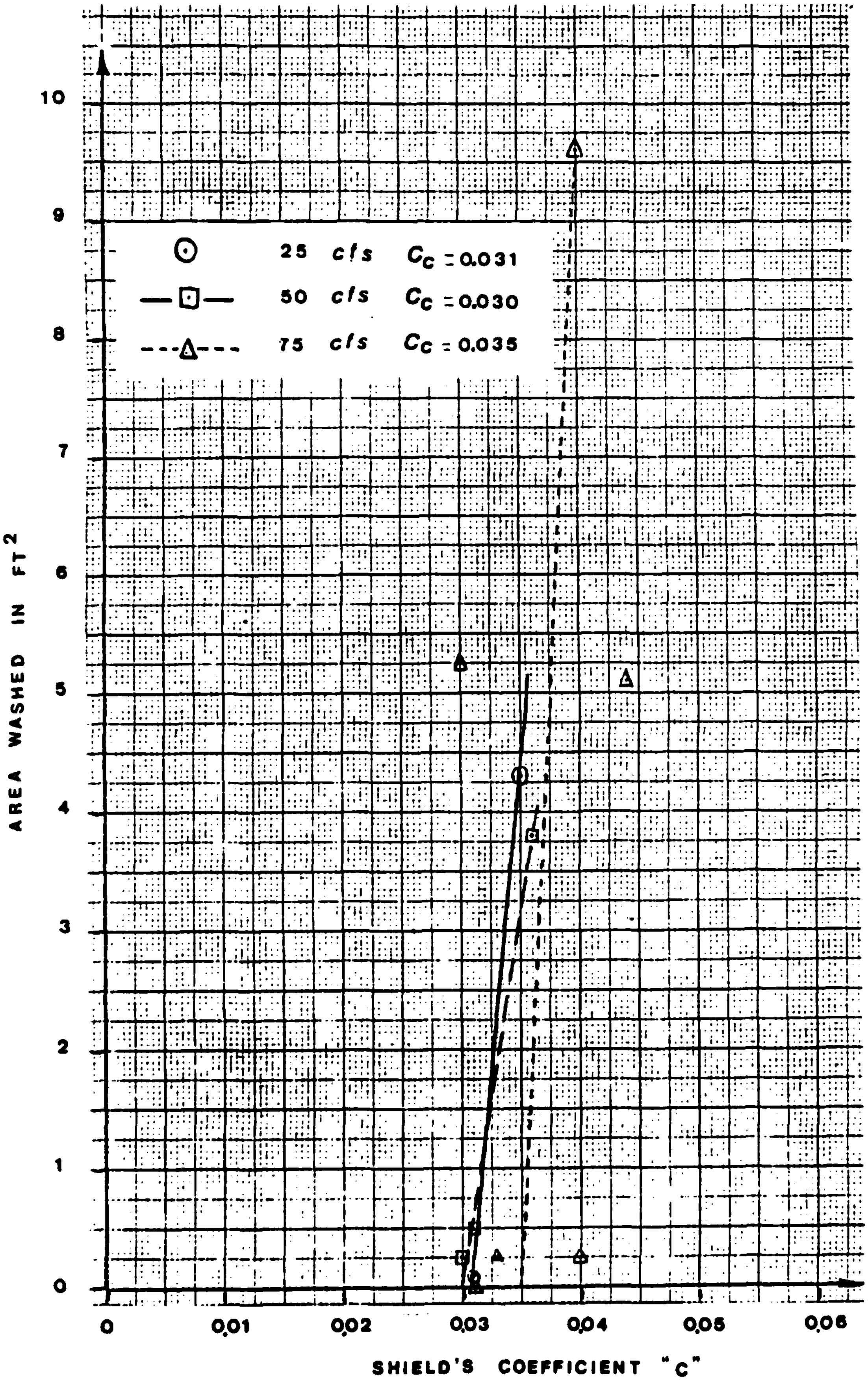


Figure 3.8. Determination of the Critical Shields Coefficient from Washed Areas for 1 inch Riprap.

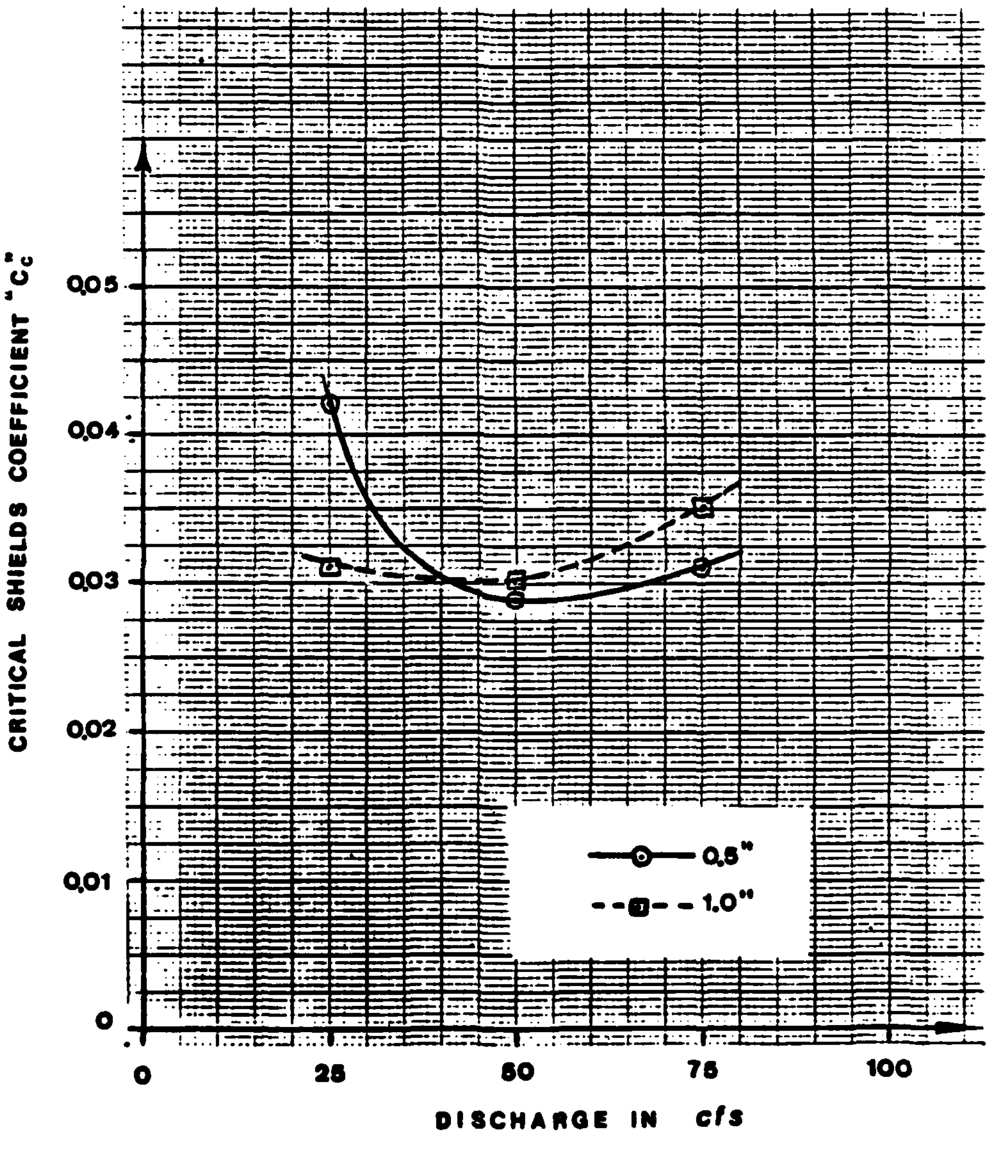


Figure 3.9. Variation of the Critical Shields Coefficient with Discharge

3.4 Maximum Stable Slopes at the Incipient Motion Conditions

The maximum stable slopes corresponding to the incipient motion conditions of riprap are selected from Tables 3.1 and 3.2 and are plotted in Fig. 3.10. If this figure is superimposed on Fig. 3.14 of the 1982 report, it will be observed that the maximum stable slopes agree together, i.e., the 3/4 inch riprap curve would fall between the two curves shown in Fig. 3.10.

3.5 Comparisons with Shields Diagram

Values of the critical Shields coefficient as determined from Fig. 3.7 and 3.8 are plotted in Fig. 3.11. The figure also contains all the other information included in the 1982 report. The values of the boundary Reynolds numbers were obtained from Tables 3.1 and 3.2. The range of the critical Shields coefficients are well within the expected values. One relatively high value for the 0.5 inch riprap at 25 cfs is a result of plotting through scattered data on Fig. 3.7. Table 3.1 shows that at run No. 8, the incipient motion condition for this case, Shields coefficient is only 0.035.

3.6 Determination of Bed Critical Shields Coefficient

The tests conducted under maximum stable slopes were considered incipient motion runs, for which the values of bed Shields coefficient can be determined. Equation 3.4 is used for this purpose, and the value of the Shields coefficient found is denoted as C_{cb}, indicating the incipient motion conditions for the bed. The summary of these tests is shown in Table 3.3. The table contains values of f_b and C_{cb} resulting from Eq. 3.4. The last column in Table 3.3 contains the values of C_c determined from the washed area analysis of Section 3.3 for comparison. The values of C_{cb} are expected to be lower than the

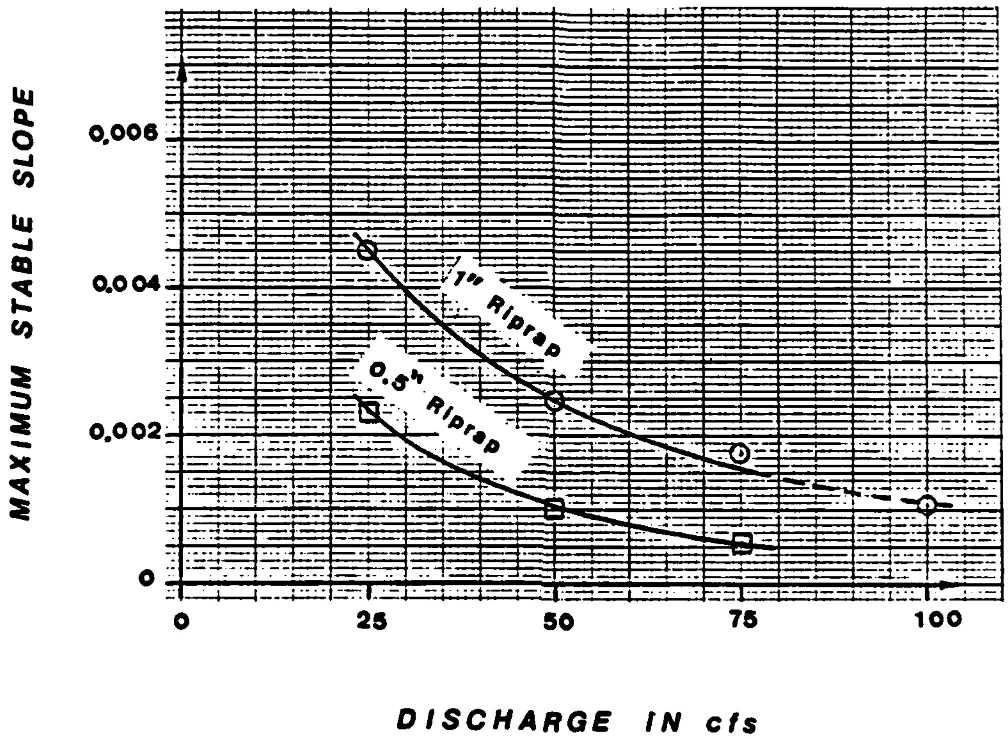


Figure 3.10. Variation of the Maximum Stable Slope with Discharge for the Two Sizes

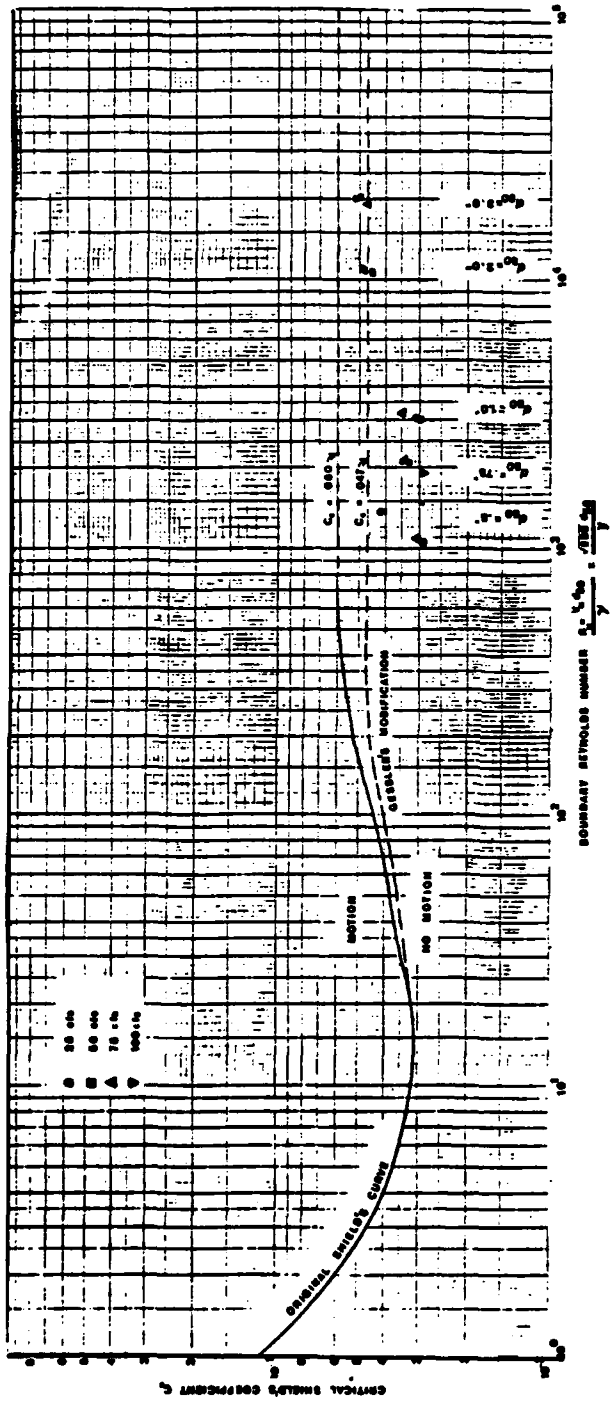


Figure 3.11. The Shields Diagram

Table 3.3. Calculation of Bed Critical Shields Coefficient

Median Size (in)	Run No.	Nominal Discharge (cfs)	Slope	Aver. Velocity (fps)	Aver. Depth (ft)	f	f_w	f_b	R_b ft	C_{cb}	F	d_{50}/D	C_c'
0.5	8	25	0.00231	3.155	1.030	0.049	0.027	0.055	0.920	0.03	0.55	0.040	0.042
	12	50	0.00102	3.085	2.047	0.037	0.022	0.045	1.630	0.024	0.38	0.020	0.029
	16	75	0.00056	3.154	3.026	0.025	0.019	0.030	2.069	0.017	0.32	0.014	0.031
1.0	5	25	0.00451	3.373	0.926	0.077	0.030	0.088	0.862	0.028	0.62	0.090	0.031
	8	50	0.00249	3.880	1.660	0.050	0.023	0.061	1.432	0.026	0.53	0.050	0.030
	14	75	0.00176	3.796	2.442	0.048	0.022	0.064	2,034	0.026	0.43	0.034	0.035

values of C_c because the former is determined at discrete changes of test conditions while the latter is found from extrapolation of plotted results (Fig.s 3.7 and 3.8). In addition, C_c reflects the effect of the smooth flume walls while this effect has been eliminated in the calculation of C_{cb}.

3.7 Froude Number Analysis of WES

Equation 3.8 has been used to determine C_{cw}, the critical Shields coefficient using the analysis of WES. The data of $\mathbf{F}$ and d_{50}/D shown in Table 3.3 are plotted in Fig. 3.12. The equation of the line is

$$\frac{d_{50}}{D} = 0.33\ \mathbf{F}^3 \tag{3.10}$$

which by comparison to Eq. 3.8 indicates

$$\frac{26.06\ K^3}{C_{cw}^{\ 3/2}} = 0.33 \tag{3.11}$$

Values of K are determined from the equation

$$n = K\ d_{50}^{\ 1/6} \tag{3.12}$$

Tables 3.1 and 3.2 show the values of the Manning's roughness factors for the bed. Using those values, Table 3.4 is prepared. Included in the table are values of C_{cb} and C_c for comparison. The values of critical Shields coefficient show good agreement, ranging from an absolute low of 0.017 to an absolute high of 0.048. However, the common range among all the values seems to be 0.024 to 0.037. This is well within the expected range since it has been known that for stable riprap a general rule would be to use half of the original critical Shields coefficient, suggested by Shields or Gessler (Fig. 3.11).

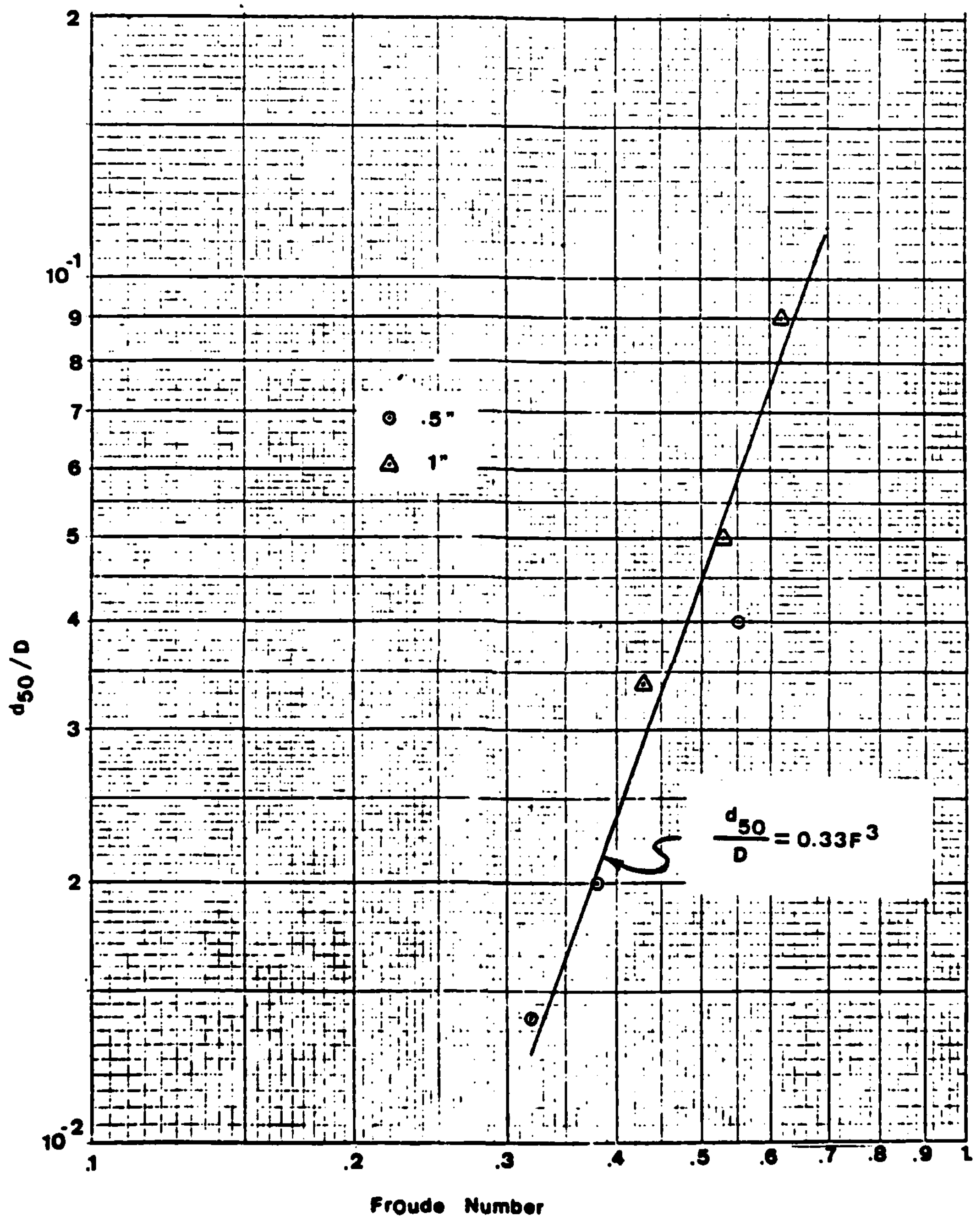


Figure 3.12. $\frac{d_{50}}{D}$ vs. Froude Number

Table 3.4. Calculation of the Critical Shields Coefficient by WES Analysis

d_{50}, in	d_{50}, ft	Q, cfs	n_b	K	C_{cw}	C_{cb}	C_c
0.5	0.0417	25	0.030	0.051	0.048	0.031	0.042
		50	0.024	0.041	0.031	0.024	0.029
		75	0.023	0.039	0.028	0.017	0.031
1.0	0.0833	25	0.030	0.045	0.037	0.028	0.031
		50	0.028	0.042	0.032	0.026	0.030
		75	0.030	0.045	0.037	0.026	0.035

Average K = 0.044 for which C_{cw} = 0.035

3.8 Specific Gravities

Four measurements of specific gravity were done in the testing period in order to determine if the washed material was lighter in weight than the original mix. The results are shown in Table 3.5. Two conclusions can be drawn from Table 3.5. First, there is no appreciable quantities of sandstone or other lightweight rock in the mix. Second, the washed material does not consist of any lightweight material.

Table 3.5. Specific Gravities of 1-inch Riprap Material

Source	Unit Weight, pcf	Specific Gravity
Original mix	166.5	2.67
Original mix	166.9	2.67
Washed material, Run No. 13	169.6	2.72
Washed material, Run No. 13	164.9	2.64

After further discussion with WES staff, a sample of the original riprap was analyzed for specific gravity. The sample was then separated into two groups: the sandstones and the remaining rocks. The

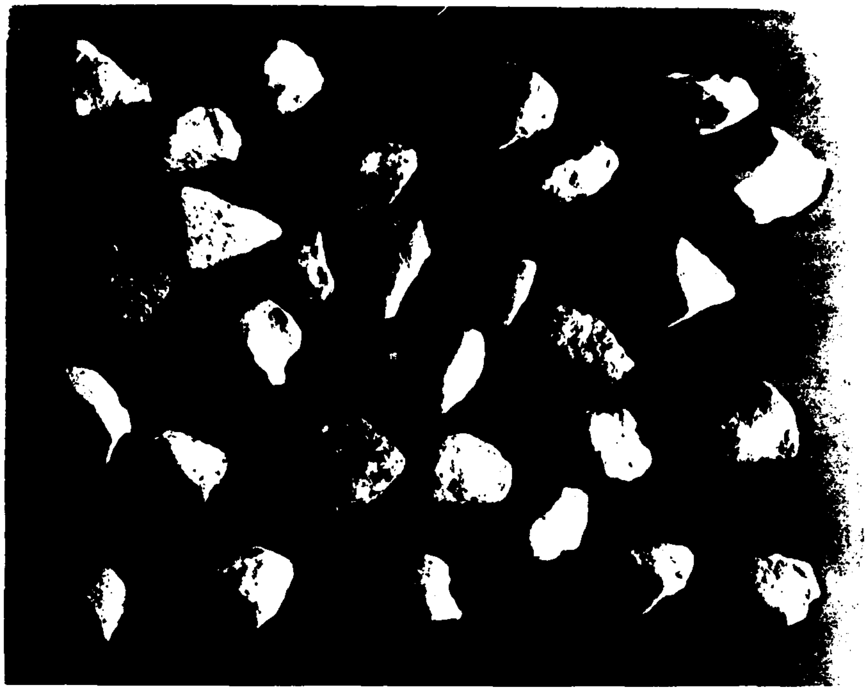
specific gravity of each group was separately measured. The results are shown in Table 3.6. It can again be concluded that the riprap material consists of uniform rocks of constant specific gravity. Figure 3.13 shows the two separated groups of riprap rock.

Table 3.6. The Specific Gravities of the Mixed Riprap

Rock type	Sample Number	Measured volume, ml	Measured volume, ft^3	Measured weight, lbs	Unit weight, pcf	Specific gravity	Average S.G. for rock type
Overall	1	727	0.0080	1.318	164.4	2.63	2.66
	2	210	0.0074	1.242	167.2	2.68	
	3	250	0.0088	1.471	166.7	2.67	
	4	260	0.0092	1.512	164.7	2.64	
	5	305	0.0108	1.782	165.4	2.65	
	6	370	0.0131	2.172	166.2	2.66	
Sandstones	1	17.0	0.00060	0.0947	157.8	2.53	2.69
	2	12.0	0.00042	0.0749	176.7	2.83	
	3	14.0	0.00049	0.0837	169.3	2.71	
Remaining Rocks	1	19.0	0.00067	0.1101	164.1	2.63	2.69
	2	27.0	0.00095	0.1542	161.7	2.59	
	3	25.0	0.00088	0.1452	164.4	2.63	
	4	23.0	0.00081	0.1333	164.1	2.63	
	5	23.0	0.00081	0.1421	173.9	2.80	
	6	27.0	0.00095	0.1712	179.5	2.88	

3.9 Armoring Effects of Riprap Surface

After the riprap layer is placed in the test section and water is routed, a certain degree of armoring will inevitably occur. The armoring happens by dislocation and reorientation of the rocks into a more stable configuration. This means the original mix remains in its entirety on the test section, except in a reoriented configuration. Otherwise, if the fine material was dislodged and moved by water, it would have been collected at the downstream trap. Such an effect was never observed.



(a) Sample of the Sandstones

(b) Sample of the Remaining Rocks

Figure 3.13. Composition of Riprap Material

Another effect of armoring would be observed in the washout patterns, attached as Appendix C of this report. When a washout spot develops, it is usually repaired by placing fresh riprap from the original mix. If significant armoring effect is present on the riprap surface, since the newly repaired surface lacks such armoring, the same area should be washed again. While this effect can be occasionally observed in the washout patterns, lack of consistency in its occurrence leads to the conclusion that the armoring effect on the riprap surface is not a primary control in the failure process. Figures 3.14 and 3.15 show pictures of the 1-inch riprap surface before any testing and after the complete set of tests.

3.10 Effect of the Froude Number on the Critical Sheilds Coefficient

It was decided, after discussions with WES staff, that the effect of Froude number on the critical Shields coefficient should be determined. For this purpose the data presented in Table 3.4 of the 1982 report and Table 3.3 of this report were plotted in Fig. 3.16. The data show indication of a linear relationship between the critical bed Shields coefficient and the Froude number. However, there is substantial scatter in the data and until additional data become available, the use of Fig. 3.16 is not recommended.

3.11 Design of Stable Riprap

Considering the results presented in this report and the 1982 report, the range of critical Shields coefficients for design of riprap is limited. The analyses presented in these reports are not all inclusive, and further refinement and analysis is possible. For example, comparing Fig. 3.12 of this report to Fig. 3.16 of the 1982 report suggests that while a slope of 3:1 for the plot of **F** vs. d_{50}/D is

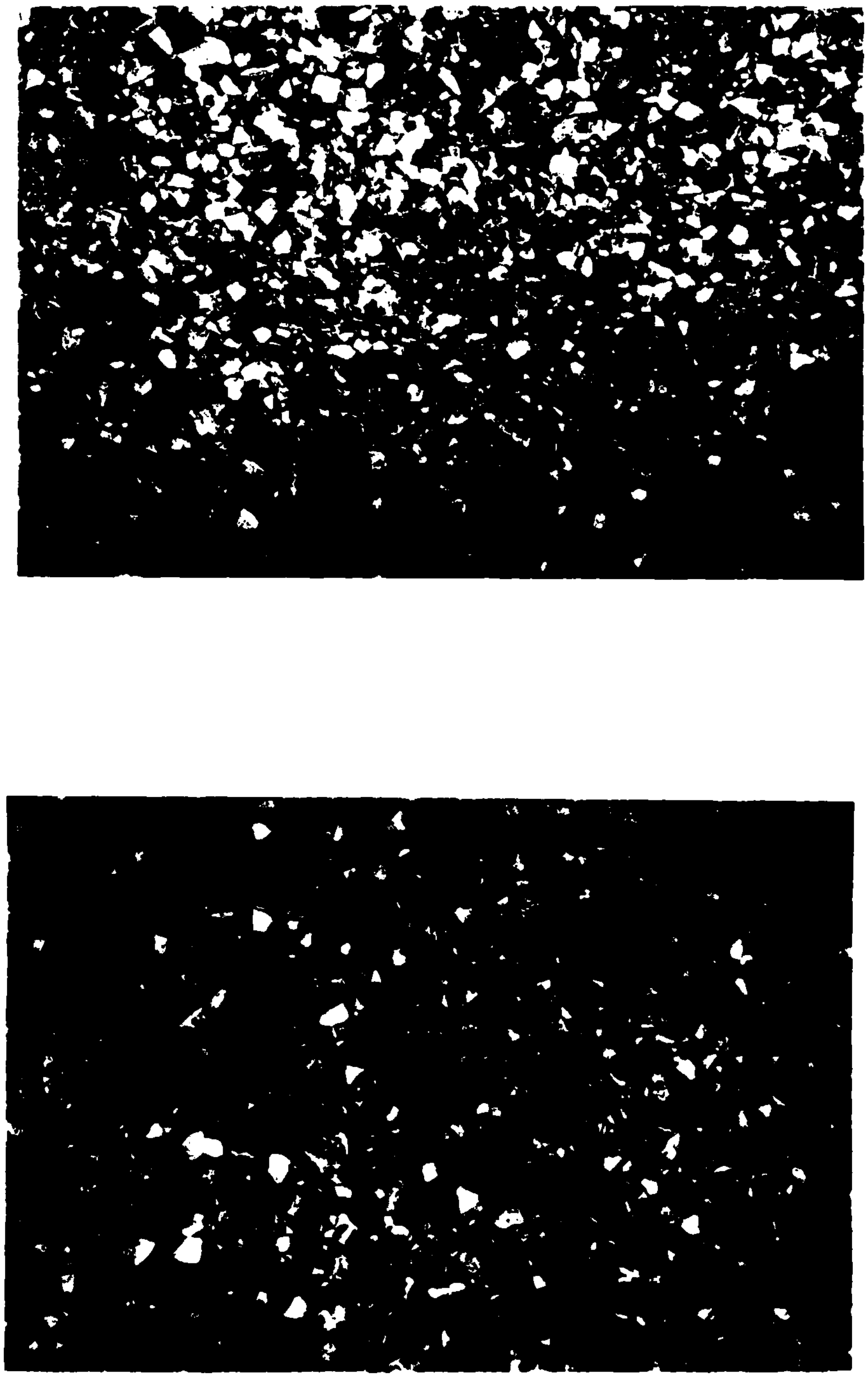


Figure 3.14. The Original Riprap Surface

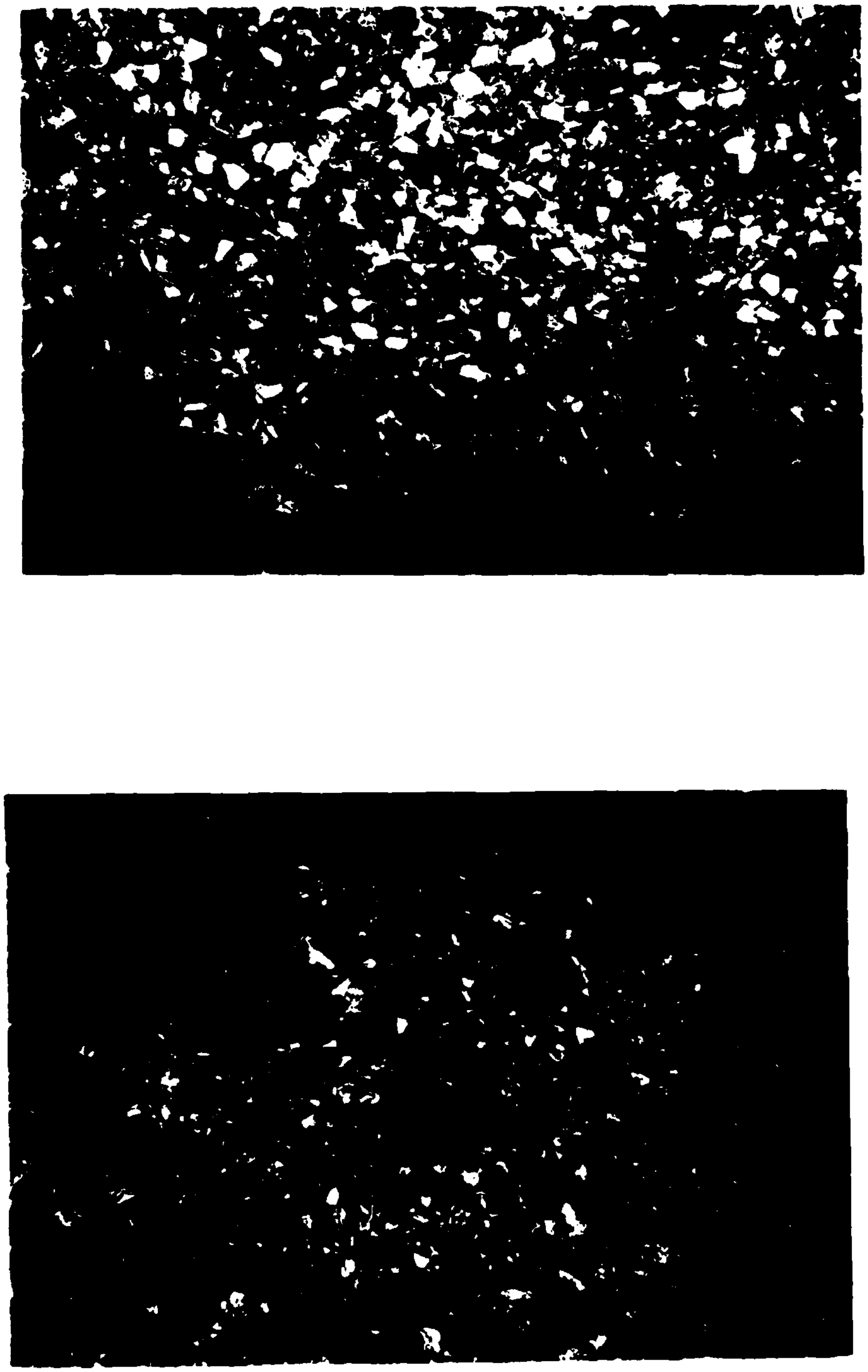


Figure 3.15. The Riprap Surface after Test Number 15

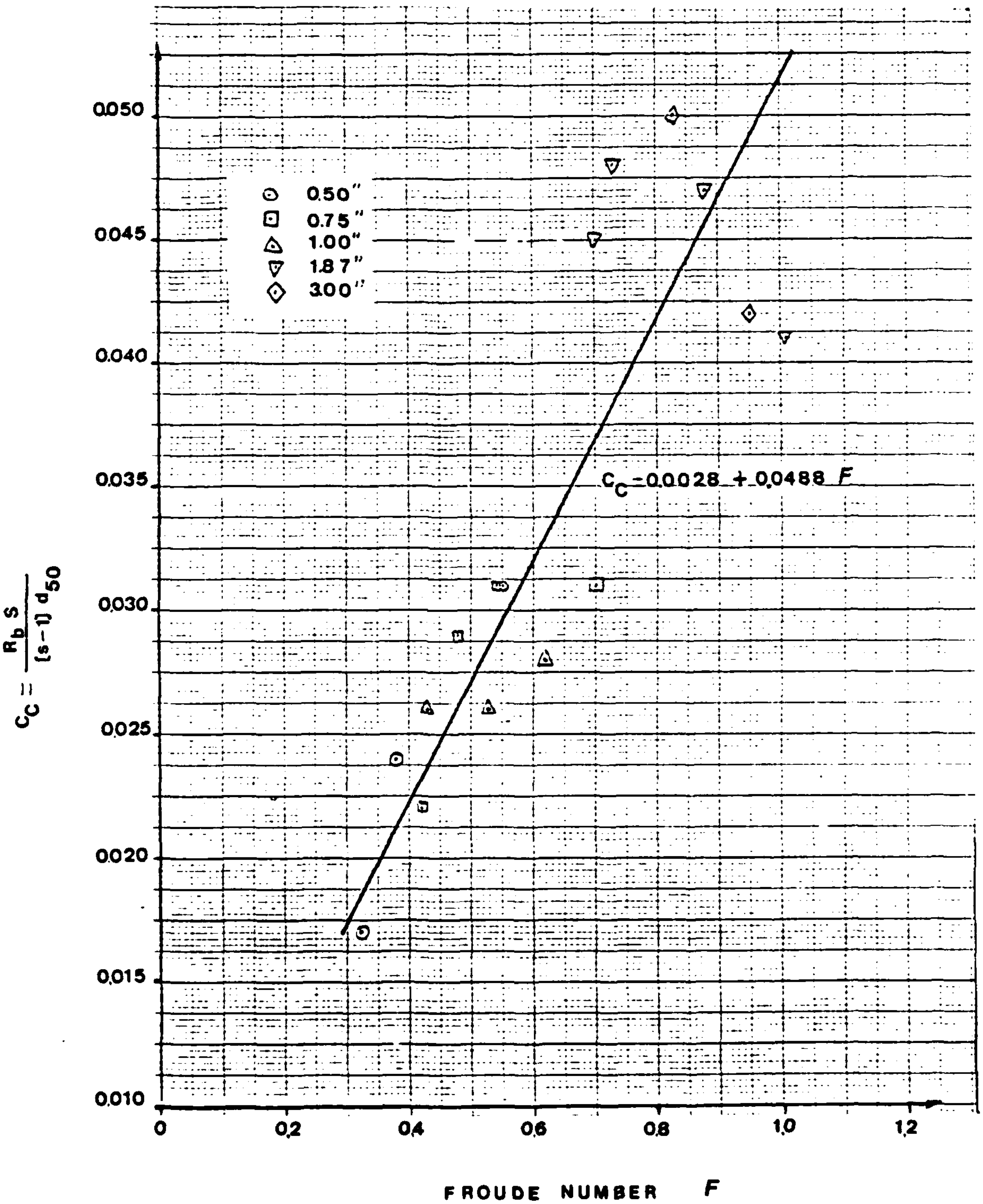


Figure 3.16. Variation of the Bed Critical Shields Coefficient with the Froude Number

appropriate, the coefficient does change and there may be envelope curves to be fitted if more extensive data were available. At the present level of information, the procedure for designing stable riprap is essentially the same as proposed in the 1982 report.

Chapter 4

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A total of 32 tests were conducted on ripraps of 0.5-inch and 1-inch median size at discharges of 25, 50, 75, and 100 cfs. The tests were conducted at the 8 ft tilting flume of the Hydraulics Laboratory, Engineering Research Center of Colorado State University. The flume slope was increased for each size and each discharge, until riprap failure was observed. The slope was then reduced and the test repeated to ensure stability of the riprap surface. These runs were called incipient motion runs. Depth and velocity data were collected during all runs, with more extensive data taken at the incipient motion runs. For the runs with riprap failure, size analyses of the washed material that were trapped downstream were also performed. The complete data are attached in the appendix to the report.

The preparation of the riprap material, construction of the study section, experimental facilities and data collection program were explained in Chapter 2. The data analyses were performed in Chapter 3. Numerous conclusions were drawn from the data analyses as listed briefly below:

1. The values of the Shields coefficient at the incipient motion conditions range from 0.017 to 0.048 for the riprap tested in this study.
2. Careful study of Table 3.4 shows that when the effect of the flume walls are eliminated, the resulting values of the

critical Shields coefficients are slightly lower than other methods. While this difference may be partially due to the method of analysis, as mentioned in Section 3.6, further analysis and careful study of the flume wall effect may prove useful.

3. The results of these tests are generally consistent with the results obtained earlier on coarser riprap sizes.
4. For design of stable riprap, the critical Shields coefficient should be about half of the original values suggested by Shields or Gessler.
5. Although the data indicate a correlation between the Froude number and the critical Shields coefficient, there is considerable scatter in the data and the effect of Froude number on the Shields coefficient cannot be well defined.

The analyses presented in this report and in the 1982 report can be expanded and refined to provide a more accurate assessment of the role of different variables on the stability of riprap. For a more comprehensive understanding of the riprap stability, additional studies are recommended in the areas listed below:

1. The effect of gradation of the riprap mixtures on the stability against movement or the critical Shields coefficient needs to be studied.
2. The effect of varying Froude number on the critical Shields coefficient or the Shields diagram should be determined.
3. The performance of riprap on channel banks should be studied. The stable bank slopes for a certain riprap size and gradation and under certain ranges of Froude number or other flow variables should be determined.

4. Criteria for the stability and incipient motion of riprap surfaces should be developed through future studies. Diagrams similar to Shields may be developed for use in the design of stable riprap.
5. The stability of a riprap surface may vary substantially under clear water flows vs. heavily sediment-laden flows. This factor needs to be studied and the extent of its effect on stability criteria should be determined.
6. The gaps between the existing data, such as shown in Fig. 3.16 should be filled and the extent of data should be expanded for conclusive results. Specifically, tests on riprap median sizes of 1.5, 4, 5, and 6 inches are recommended.

The items listed above require comprehensive and detailed studies in order to clarify all the concepts in existence for design of stable ripraps. The existing flumes and experimental facilities at Colorado State University have the capability of conducting detailed studies on any of the items listed above, or combining several of the items in one comprehensive study.

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Appendix A

Summary

Table A-1. Summary of the Tests Conducted for the 0.5-inch Riprap

Run No.	Orifice Discharge cfs	Flume Slope $x10^5$	Water Temperature °F	Washout Area sq.ft.	Washout Area Map(1)	Depth and Velocity Data Page(2)	Washed Sediment Size Analysis Page(3)
1	25	143	64	-	-	52	-
2		185	70	-	-	52	-
3		231	70	-	-	52	-
4		280	65	-	-	52	-
5		331	70	0.76	59	52	-
6		331	73	36.86	60	52	86
7		280	75	5.70	61	53	86
8		231	70	6.08	62	53	87
9	50	102	70	1.14	63	53	-
10		128	75	3.04	64	53	87
11		154	72	20.52	65	53	-
12		102	74	1.00	66	54	88
13	75	72	74	0.70	67	54	88
14		90	74	5.00	68	54	89
15		72	74	11.70	69	54	89
16		56	74	-	70	54	-
17	100	56	74	5.70	71	55	90

(1) Appendix C

(2) Appendix B

(3) Appendix D

Table A-2. Summary of the Tests Conducted for the 0.5-inch Riprap

Run No.	Orifice Discharge cfs	Flume Slope $\times 10^5$	Water Temperature °F	Washout Area sq.ft.	Washout Area Map(1)	Depth and Velocity data Page(2)	Washed Sediment Size Analysis Page(3)
1	25	348	73	-	72	55	-
2		451	74	-	-	55	-
3		451	74	-	-	55	-
4		562	70	4.30	73	55	90
5		451	73	0.07	74	55	91
6	50	249	70	0.50	75	56	91
7		310	71	3.80	76	56	92
8		249	70	0.25	77	56	92
9	75	176	72	5.25	78	56	-
10		176	70	0.25	79	56	-
11		219	70	0.25	80	57	93
12		265	-	5.10	81	57	93
13		219	60	9.60	82	57	94
14		176	78	-	83	57	-
15	100	106	77	1.50	84	57	94

(1) Appendix C

(2) Appendix B

(3) Appendix D

Appendix B

Depth and Velocity Data

RIPRAP SIZE=0.50 IN Q=25.CFS SLOPE=0.00143 RUN NO. 1

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.445	2.25	1.86
25.	4.	1.414	2.43	.80
40.	4.	1.444	2.42	.82

RIPRAP SIZE=0.50 IN Q=25.CFS SLOPE=0.00185 RUN NO. 2

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.326	2.72	1.91
25.	4.	1.336	2.60	1.92
40.	4.	1.342	2.57	1.89

RIPRAP SIZE=0.50 IN Q=25.CFS SLOPE=0.00231 RUN NO. 3

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.263	2.67	1.94
25.	4.	1.279	2.62	2.16
40.	4.	1.290	2.77	2.18

RIPRAP SIZE=0.50 IN Q=25.CFS SLOPE=0.00280 RUN NO. 4

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.120	3.23	2.23
25.	4.	1.080	3.23	2.37
40.	4.	1.119	3.21	2.40

RIPRAP SIZE=0.50 IN Q=25.CFS SLOPE=0.00331 RUN NO. 5

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.022	3.33	2.40
25.	4.	1.005	3.59	2.43
40.	4.	1.037	3.35	2.54

RIPRAP SIZE=0.50 IN Q=25.CFS SLOPE=0.00331 RUN NO. 6

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.915	3.59	2.62
25.	4.	.921	3.84	2.54
40.	4.	.930	3.66	2.50

RIPRAP SIZE=0.50 IN Q=25.CFS SLOPE=0.00280 RUN NO. 7

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	.981	3.81	5.40	3.44	3.06	2.21
10.	4.00	.984	3.91	3.52	3.21	2.77	2.05
10.	6.67	1.011	4.18	3.89	3.67	3.08	2.13
25.	1.33	.989	3.79	3.64	3.35	2.89	2.03
25.	4.00	.984	3.66	3.42	3.16	2.87	2.03
25.	6.67	1.002	4.20	3.83	3.52	3.04	2.17
40.	1.33	1.012	3.71	3.62	3.25	2.65	1.70
40.	4.00	1.021	3.64	3.49	3.33	2.89	2.13
40.	6.67	.978	3.81	3.67	3.47	3.08	2.13

RIPRAP SIZE=0.50 IN Q=25.CFS SLOPE=0.00231 RUN NO. 8

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	1.007	3.79	3.57	3.40	3.03	2.28
10.	4.00	1.053	3.49	3.33	3.03	2.69	1.89
10.	6.67	1.037	3.96	3.94	3.57	3.08	2.40
25.	1.33	1.029	3.59	3.54	3.30	2.77	2.01
25.	4.00	1.032	3.55	3.37	3.18	2.94	2.15
25.	6.67	1.007	4.13	3.72	3.37	2.84	2.08
40.	1.33	1.047	3.66	3.49	3.20	2.79	1.79
40.	4.00	1.056	3.52	3.35	3.23	2.81	2.04
40.	6.67	1.005	3.71	3.59	3.32	2.86	2.16

RIPRAP SIZE=0.50 IN Q=50.CFS SLOPE=0.00102 RUN NO. 9

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.990	3.47	2.29
25.	4.	1.929	3.23	2.44
40.	4.	1.963	3.40	2.30

RIPRAP SIZE=0.50 IN Q=50.CFS SLOPE=0.00128 RUN NO. 10

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.903	3.69	2.64
25.	4.	1.882	3.67	2.57
40.	4.	1.897	3.59	2.65

RIPRAP SIZE=0.50 IN Q=50.CFS SLOPE=0.00154 RUN NO. 11

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.801	3.76	2.74
25.	4.	1.805	3.79	2.65
40.	4.	1.810	3.52	2.59

RIPRAP SIZE=0.50 IN Q=50.CFS SLOPE=0.00102 RUN NO. 12

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	2.059	3.20	3.59	3.49	2.98	2.35
10.	4.00	2.044	3.61	3.35	3.03	2.57	2.01
10.	6.67	2.064	3.44	3.72	3.50	3.06	2.35
25.	1.33	2.042	3.21	3.45	3.35	3.10	2.30
25.	4.00	2.031	3.61	3.27	3.01	2.84	2.23
25.	6.67	2.059	3.38	3.61	3.49	3.08	2.43
40.	1.33	2.044	3.27	3.47	3.33	2.99	2.30
40.	4.00	2.039	3.45	3.37	3.20	2.93	2.32
40.	6.67	2.039	3.38	3.52	3.35	3.03	2.35

RIPRAP SIZE=0.50 IN Q=75.CFS SLOPE=0.00072 RUN NO. 13

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.953	3.99	2.87
25.	4.	2.956	3.82	2.98
40.	4.	2.966	3.65	3.14

RIPRAP SIZE=0.50 IN Q=75.CFS SLOPE=0.00090 RUN NO. 14

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.719	4.16	3.06
25.	4.	2.714	3.99	3.23
40.	4.	2.739	3.91	3.31

RIPRAP SIZE=0.50 IN Q=75.CFS SLOPE=0.00072 RUN NO. 15

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	2.864	3.23	3.74	3.57	3.23	2.47
10.	4.00	2.888	4.08	3.91	3.65	3.23	2.55
10.	6.67	2.866	3.74	3.82	3.57	3.14	2.89
25.	1.33	2.841	3.31	3.57	3.48	3.23	2.38
25.	4.00	28.440	3.99	4.08	3.65	3.57	2.64
25.	6.67	2.881	3.48	3.65	3.48	3.14	2.64
40.	1.33	2.821	3.40	3.65	3.40	3.23	2.47
40.	4.00	2.881	3.82	3.91	3.82	3.65	2.72
40.	6.67	2.811	3.65	3.74	3.57	3.06	2.55

RIPRAP SIZE=0.50 IN Q=75.CFS SLOPE=0.00056 RUN NO. 16

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	3.028	3.20	3.48	3.31	2.98	2.21
10.	4.00	3.038	3.91	3.57	3.31	3.20	2.47
10.	6.67	3.011	3.31	3.57	3.40	2.98	2.38
25.	1.33	3.020	3.74	3.23	3.23	3.20	2.47
25.	4.00	3.039	3.73	3.65	3.40	3.20	2.39
25.	6.67	3.020	3.31	3.57	33.40	3.14	2.55
40.	1.33	3.030	3.23	3.40	3.20	3.15	2.38
40.	4.00	3.037	3.48	3.65	3.31	3.20	2.38
40.	6.67	3.011	3.48	3.48	3.31	3.14	2.47

RIPRAP SIZE=0.50 IN Q=96.CFS SLOPE=0.00056 RUN NO. 17

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	3.570	4.01	2.98
25.	4.	3.540	3.99	3.06
40.	4.	3.540	3.82	2.89

RIPRAP SIZE=1.00 IN Q=25.CFS SLOPE=0.00348 RUN NO. 1

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.052	3.50	2.45
25.	4.	1.052	3.52	2.49
40.	4.	1.038	3.49	2.26

RIPRAP SIZE=1.00 IN Q=25.CFS SLOPE=0.00451 RUN NO. 2

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.952	3.35	1.92
25.	4.	.971	3.38	1.99
40.	4.	.977	3.32	1.92

RIPRAP SIZE=1.00 IN Q=25.CFS SLOPE=0.00451 RUN NO. 3

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.993	3.59	2.41
25.	4.	.949	3.57	2.55
40.	4.	.992	3.55	2.49

RIPRAP SIZE=1.00 IN Q=25.CFS SLOPE=0.00562 RUN NO. 4

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	.853	4.17	2.47
25.	4.	.849	4.32	2.74
40.	4.	.843	4.51	2.37

RIPRAP SIZE=1.00 IN Q=25.CFS SLOPE=0.00451 RUN NO. 5

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	.916	4.44	4.35	4.05	3.06	2.01
10.	4.00	.921	4.25	3.74	3.62	2.89	1.96
10.	6.67	.920	4.93	4.56	3.93	3.16	1.91
25.	1.33	.933	4.10	4.00	3.83	3.20	2.19
25.	4.00	.953	4.08	3.79	3.59	2.96	1.84
25.	6.67	.906	4.51	4.19	3.67	3.21	2.16
40.	1.33	.940	4.23	3.94	3.47	2.93	1.86
40.	4.00	.919	4.03	3.85	3.47	2.94	1.94
40.	6.67	.924	4.17	4.01	3.62	3.18	1.81

RIPRAP SIZE=1.00 IN Q=50.CFS SLOPE=0.00249 RUN NO. 6

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.681	4.33	3.06
25.	4.	1.709	4.08	2.89
40.	4.	1.677	4.16	2.89

RIPRAP SIZE=1.00 IN Q=50.CFS SLOPE=0.00310 RUN NO. 7

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	1.584	3.99	3.23
25.	4.	1.585	4.25	3.06
40.	4.	1.573	4.42	2.98

RIPRAP SIZE=1.00 IN Q=50.CFS SLOPE=0.00249 RUN NO. 8

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	1.660	4.50	4.42	4.25	3.57	2.89
10.	4.00	1.662	4.42	4.16	3.99	3.65	2.81
10.	6.67	1.665	4.59	4.33	4.16	3.57	2.89
25.	1.33	1.661	4.59	4.42	4.25	3.65	3.06
25.	4.00	1.659	4.50	4.25	3.99	3.48	3.14
25.	6.67	1.665	4.42	4.25	3.91	3.48	2.81
40.	1.33	1.657	4.76	4.33	4.10	3.65	3.23
40.	4.00	1.651	4.59	4.16	3.82	3.40	3.06
29.	6.67	1.659	4.84	4.50	3.91	3.57	2.98

RIPRAP SIZE=1.00 IN Q=75.CFS SLOPE=0.00176 RUN NO. 9

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.320	5.01	3.31
25.	4.	2.300	5.09	3.82
40.	4.	2.294	5.18	3.74

RIPRAP SIZE=1.00 IN Q=75.CFS SLOPE=0.00176 RUN NO. 10

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.530	4.59	3.40
25.	4.	2.593	4.50	3.06
40.	4.	2.560	4.42	3.57

RIPRAP SIZE=1.00 IN Q=75.CFS SLOPE=0.00219 RUN NO. 11

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.429	4.76	3.48
25.	4.	2.422	4.59	3.65
40.	4.	2.398	4.67	3.57

RIPRAP SIZE=1.00 IN Q=75.CFS SLOPE=0.00265 RUN NO. 12

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	2.305	5.18	3.48
25.	4.	2.272	5.01	3.74
40.	4.	2.276	4.76	3.99

RIPRAP SIZE=1.00 IN Q= 75.FS SLOPE=0.00219 RUN NO. 13

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	2.380	3.82	4.25	4.25	3.74	3.06
10.	4.00	2.379	5.01	4.59	4.33	3.91	3.14
10.	6.67	2.386	4.25	4.59	4.33	4.08	3.48
25.	1.33	2.351	3.91	4.25	3.91	3.74	3.31
25.	4.00	2.364	4.93	4.84	4.25	3.82	3.48
25.	6.67	2.335	4.33	4.50	4.42	4.08	3.48
40.	1.33	2.350	3.99	4.42	4.25	3.42	3.06
40.	4.00	2.387	4.76	4.50	4.25	4.16	2.72
40.	6.67	2.370	4.42	4.33	4.25	4.16	3.40

RIPRAP SIZE=1.00 IN Q= 75.FS SLOPE=0.00176 RUN NO. 14

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.1 DEPTH FPS	VELOCITY AT 0.3 DEPTH FPS	VELOCITY AT 0.5 DEPTH FPS	VELOCITY AT 0.7 DEPTH FPS	VELOCITY AT 0.9 DEPTH FPS
10.	1.33	2.451	3.65	4.16	4.25	2.65	2.64
10.	4.00	2.451	4.76	4.42	3.91	3.65	2.81
10.	6.67	2.453	4.08	4.50	4.25	3.57	2.99
25.	1.33	2.446	3.82	4.16	3.99	3.48	2.81
25.	4.00	2.428	4.84	4.59	4.16	3.57	2.81
25.	6.67	2.443	3.91	4.16	4.16	3.65	2.64
40.	1.33	2.445	4.08	4.16	3.99	3.57	2.64
40.	4.00	2.430	4.42	4.33	4.16	3.91	2.98
40.	6.67	2.432	4.09	4.25	3.91	3.57	2.81

RIPRAP SIZE=1.00 IN Q=99.CFS SLOPE=0.00106 RUN NO. 15

DISTANCE ALONG TEST SECTION FT	DISTANCE ACROSS TEST SECTION FT	DEPTH FT	VELOCITY AT 0.2 DEPTH FPS	VELOCITY AT 0.8 DEPTH FPS
10.	4.	3.325	4.16	3.06
25.	4.	3.302	4.08	3.23
40.	4.	3.302	4.25	3.48

Appendix C

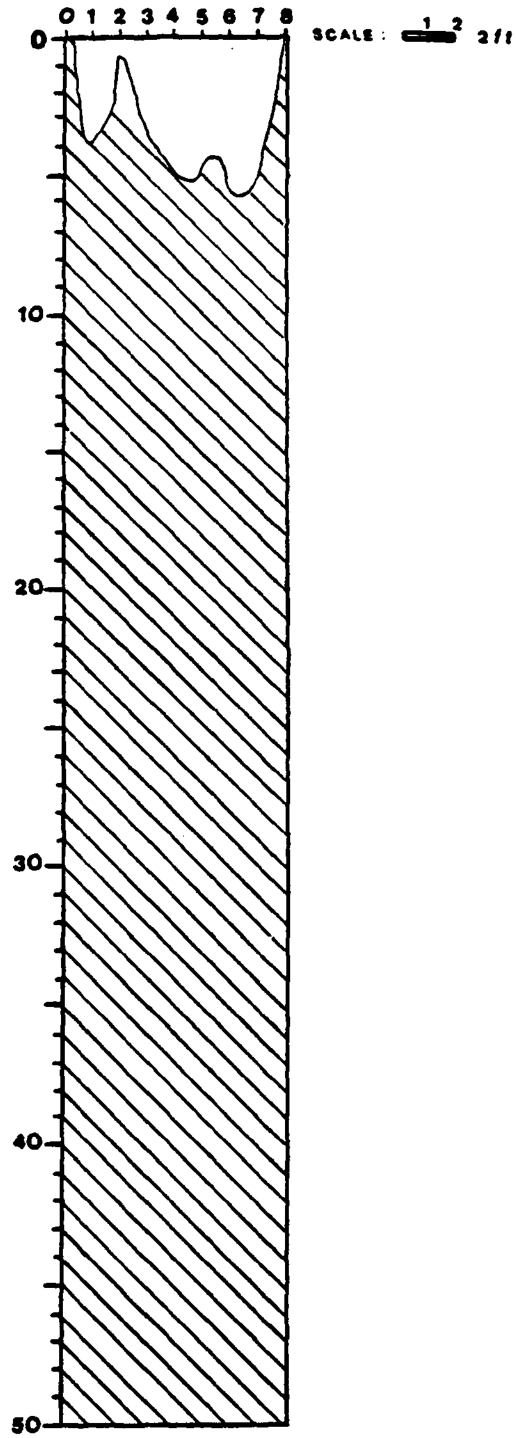
Maps of Washout Areas

RIPRAP SIZE: .50 in

RUN NO: 5

DISCHARGE: 25 cfs

SLOPE: 331 x 10^{-5}

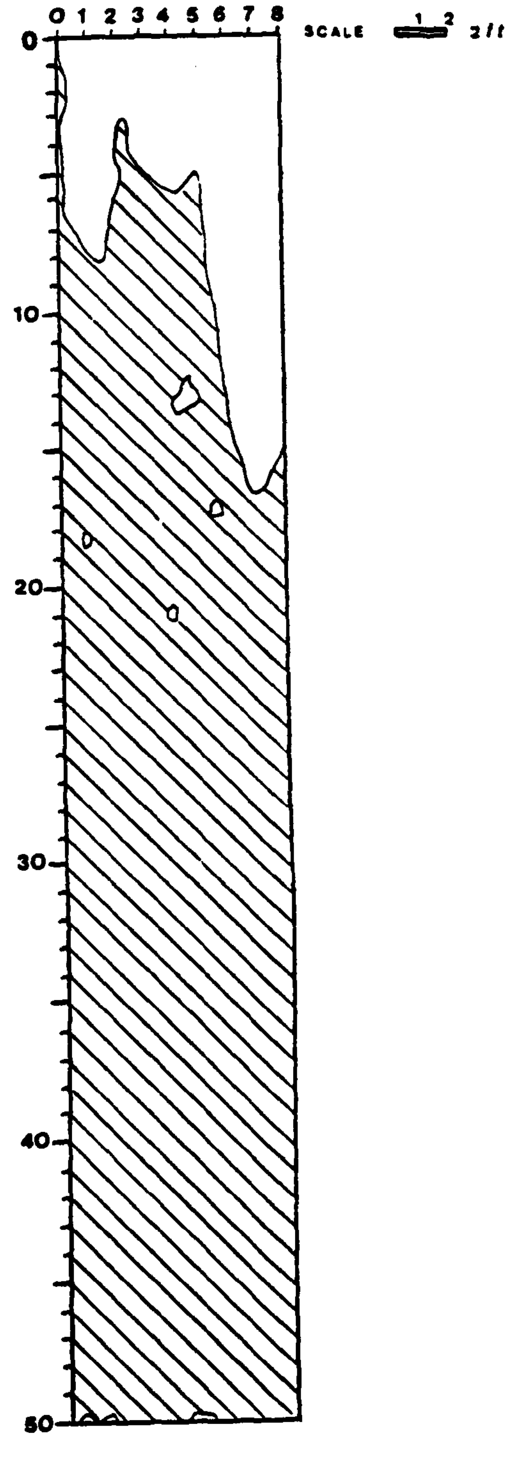


RIPRAP SIZE: .50 in

RUN NO: 6

DISCHARGE: 25 cfs

SLOPE: 331 $\times 10^{-5}$

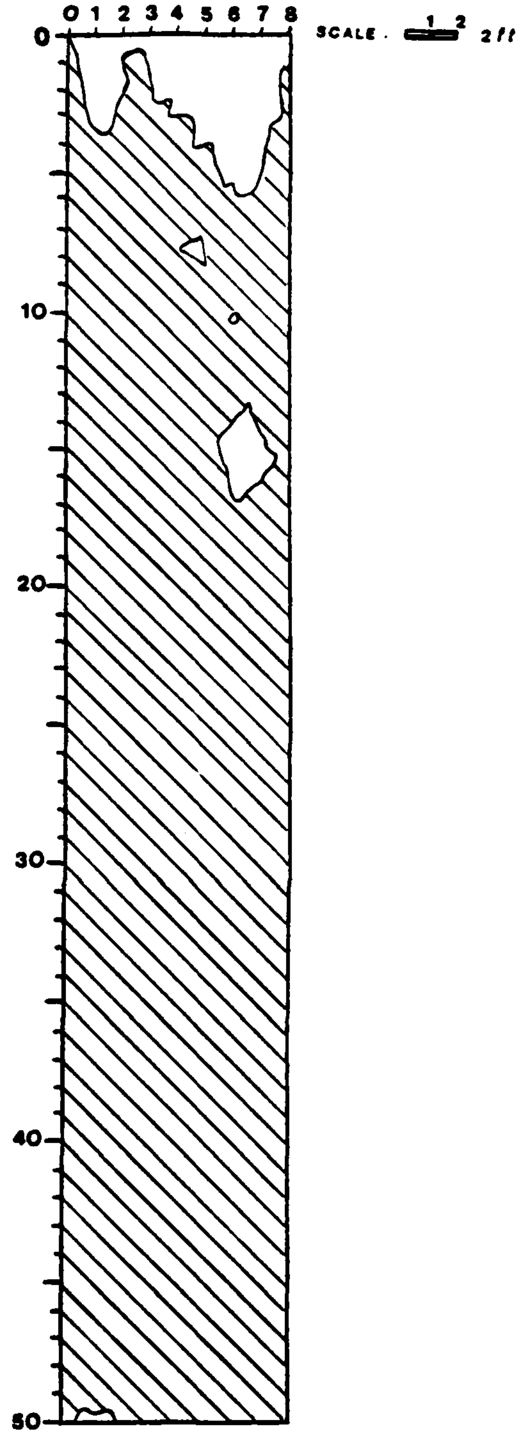


RIPRAP SIZE: .50 in

RUN NO: 7

DISCHARGE: 25 cfs

SLOPE: 280 x 10^{-5}

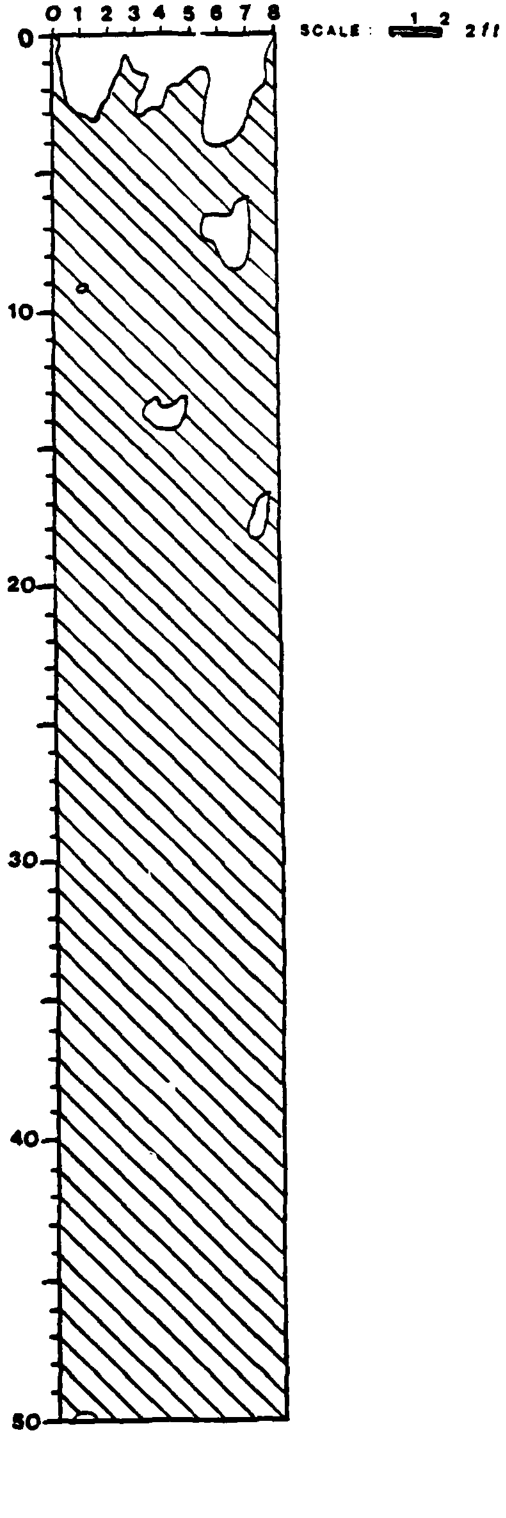


RIPRAP SIZE: .50 in

RUN NO: 8

DISCHARGE: 25 cfs

SLOPE: 231 x 10^{-5}

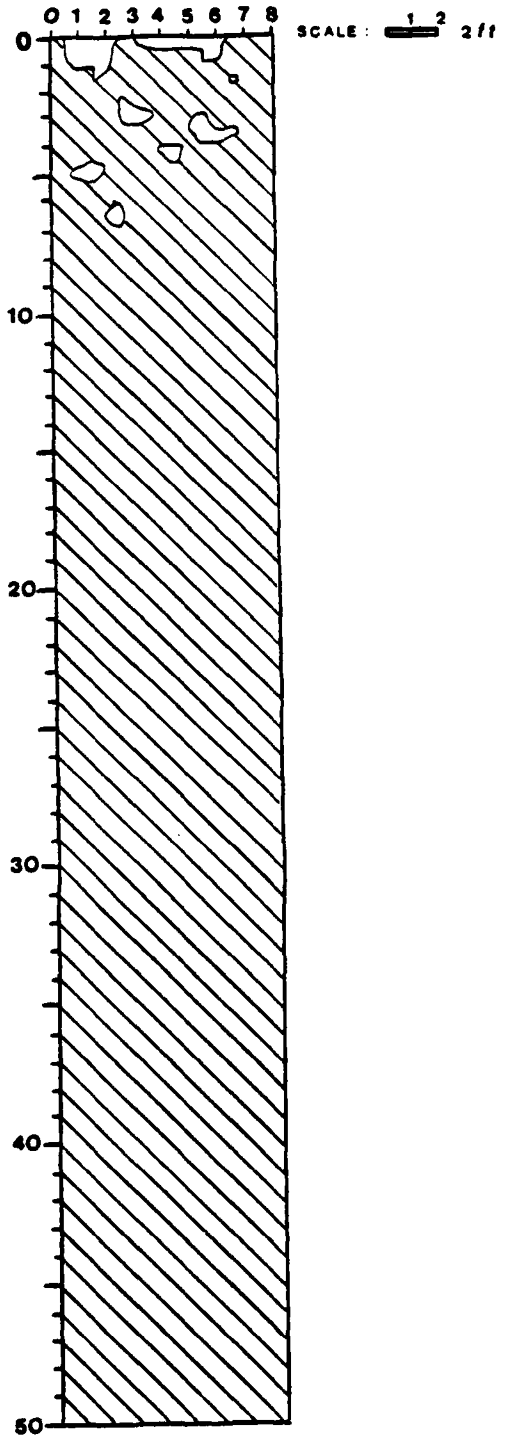


RIPRAP SIZE: .50 in

RUN NO: 9

DISCHARGE: 50 cfs

SLOPE: 102 $\times 10^{-5}$

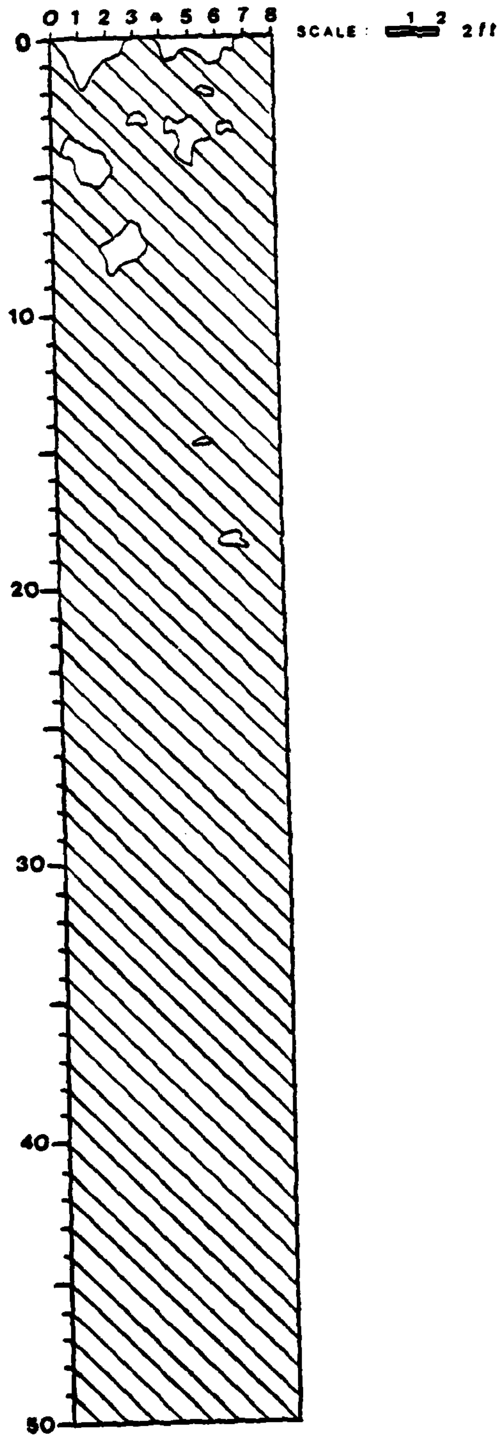


RIPRAP SIZE: .50 in

RUN NO: 10

DISCHARGE: 50 cfs

SLOPE: 128 x 10^{-5}

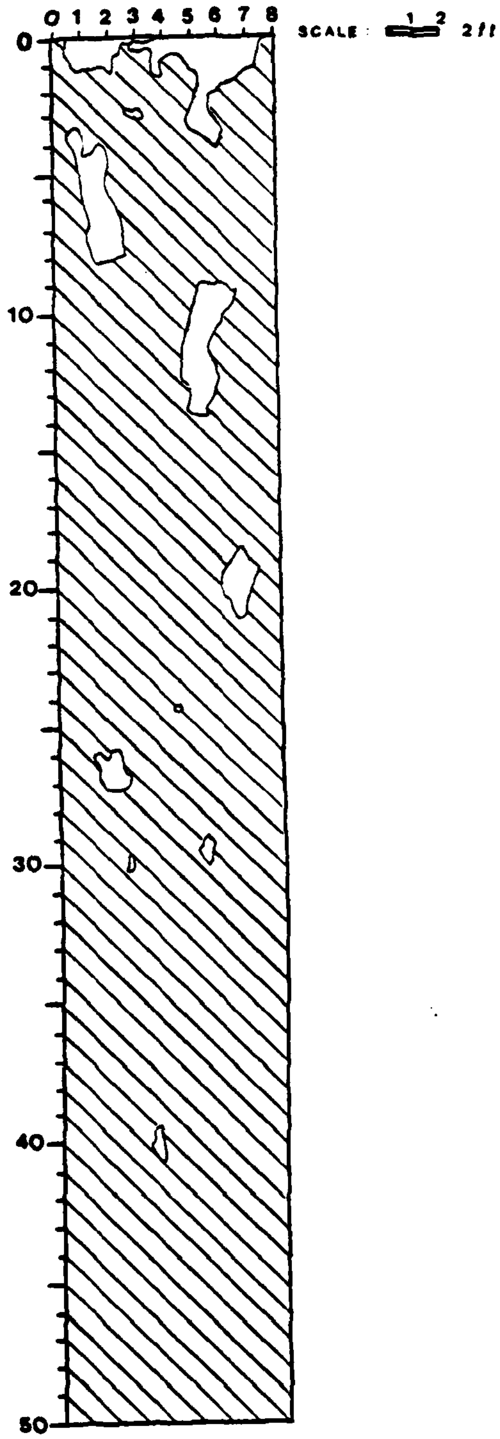


RIPRAP SIZE: .50 in

RUN NO: 11

DISCHARGE: 50 cfs

SLOPE: 154×10^{-5}

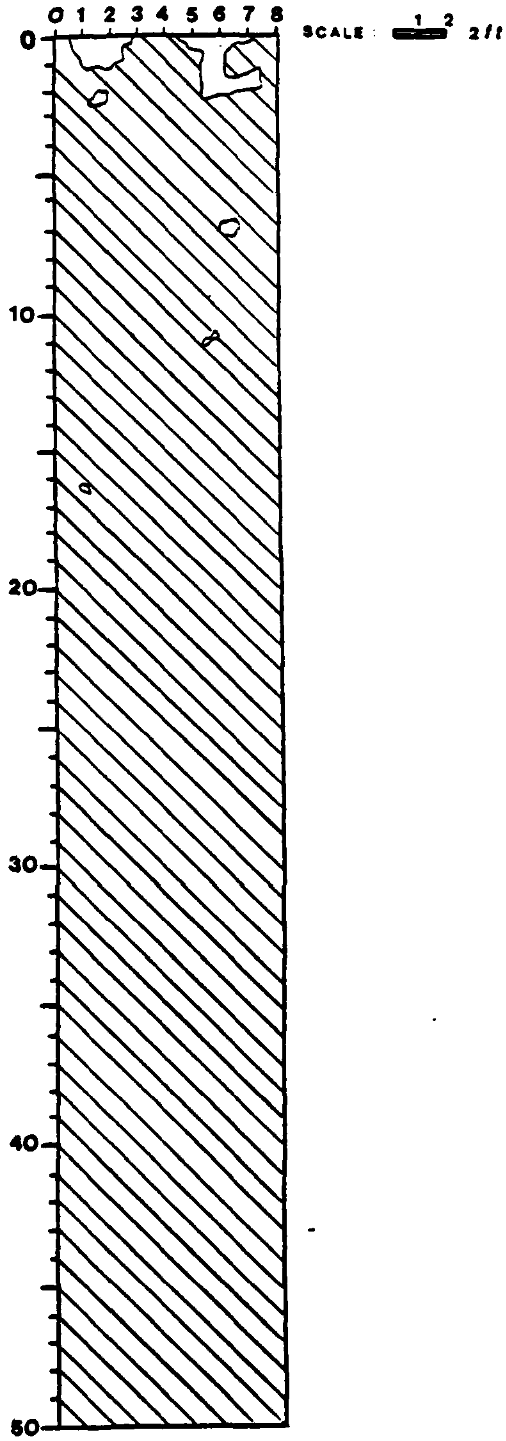


RIPRAP SIZE: .50 in

RUN NO: 12

DISCHARGE: 50 cfs

SLOPE: 102×10^{-5}

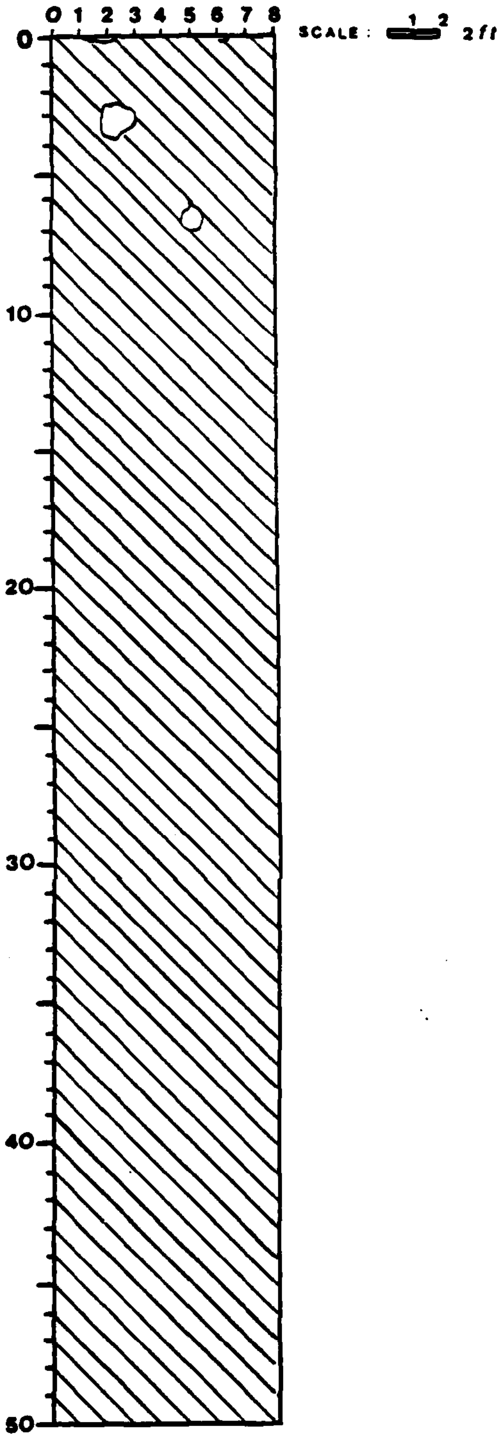


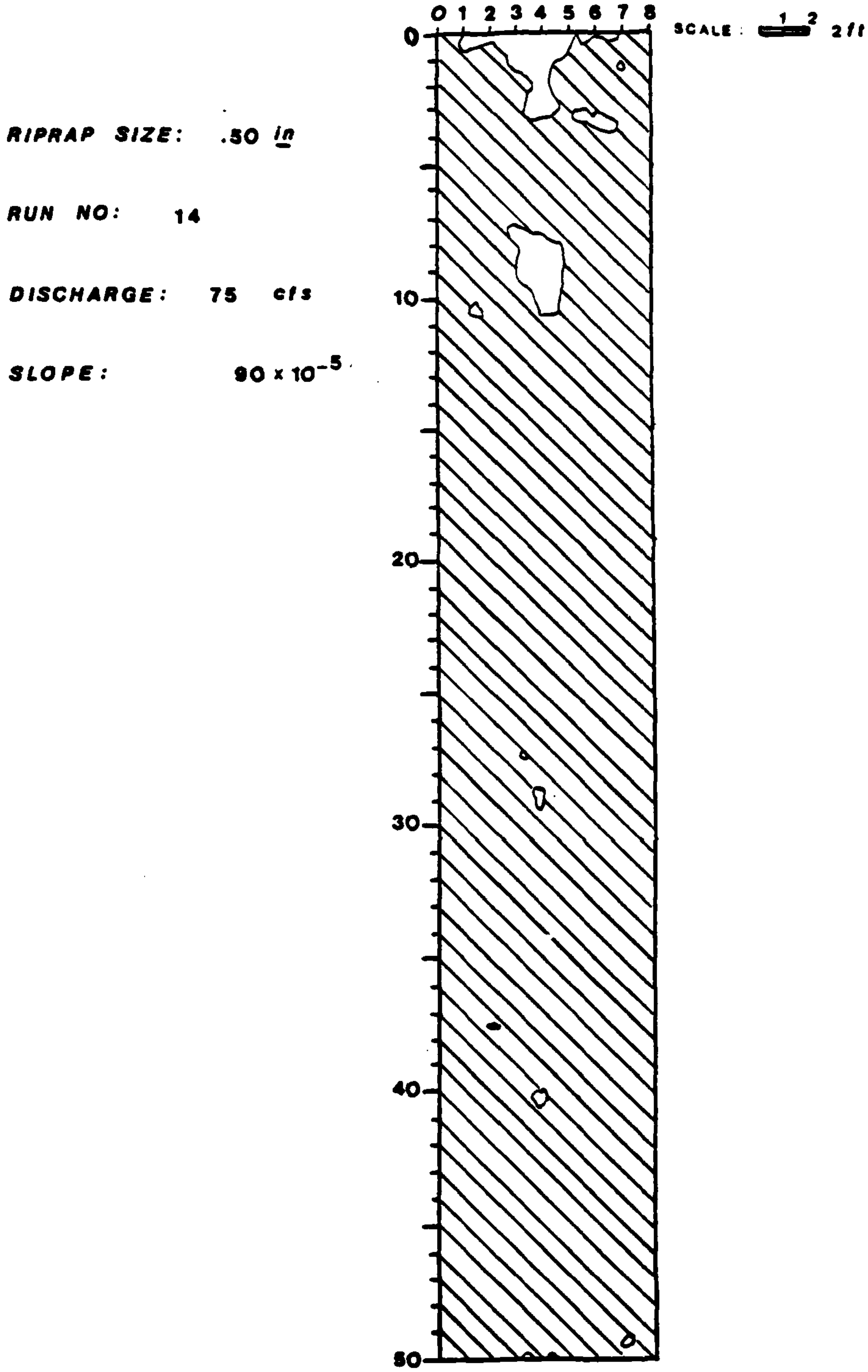
RIPRAP SIZE: .50 in

RUN NO: 13

DISCHARGE: 75 cfs

SLOPE: 72×10^{-5}





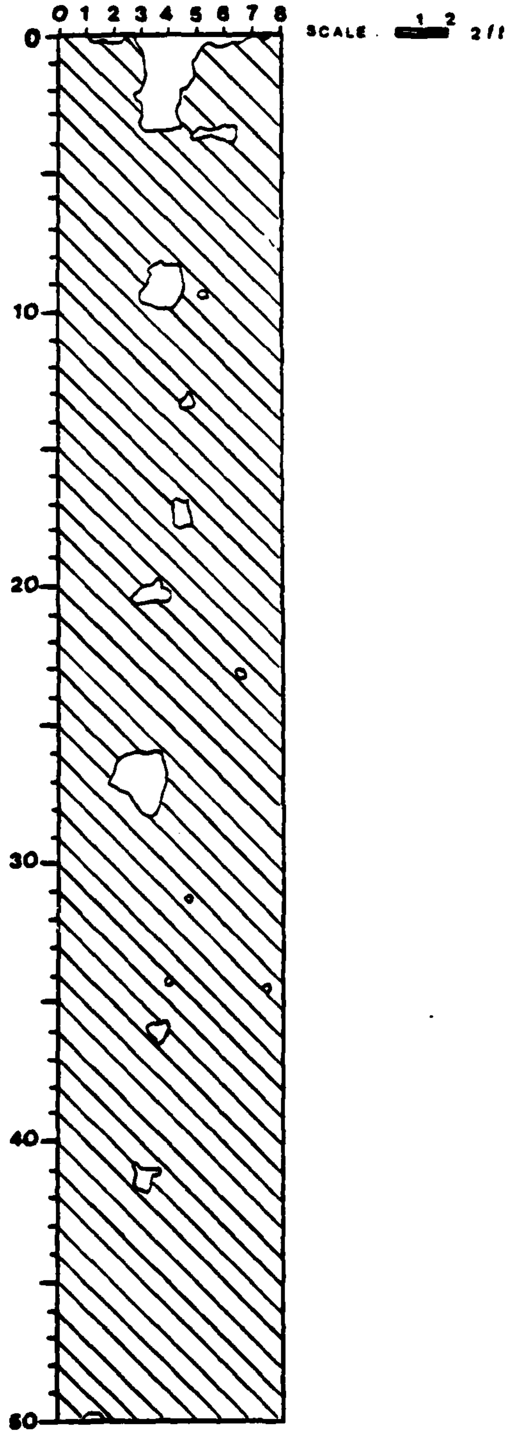
RIPRAP SIZE: .50 in
RUN NO: 14
DISCHARGE: 75 cfs
SLOPE: 90 x 10-5
0 1 2 3 4 5 6 7 8
SCALE: 1 2 2ft
0
10
20
30
40
50

RIPRAP SIZE: .50 in

RUN NO: 15

DISCHARGE: 75 cfs

SLOPE: 72×10^{-5}

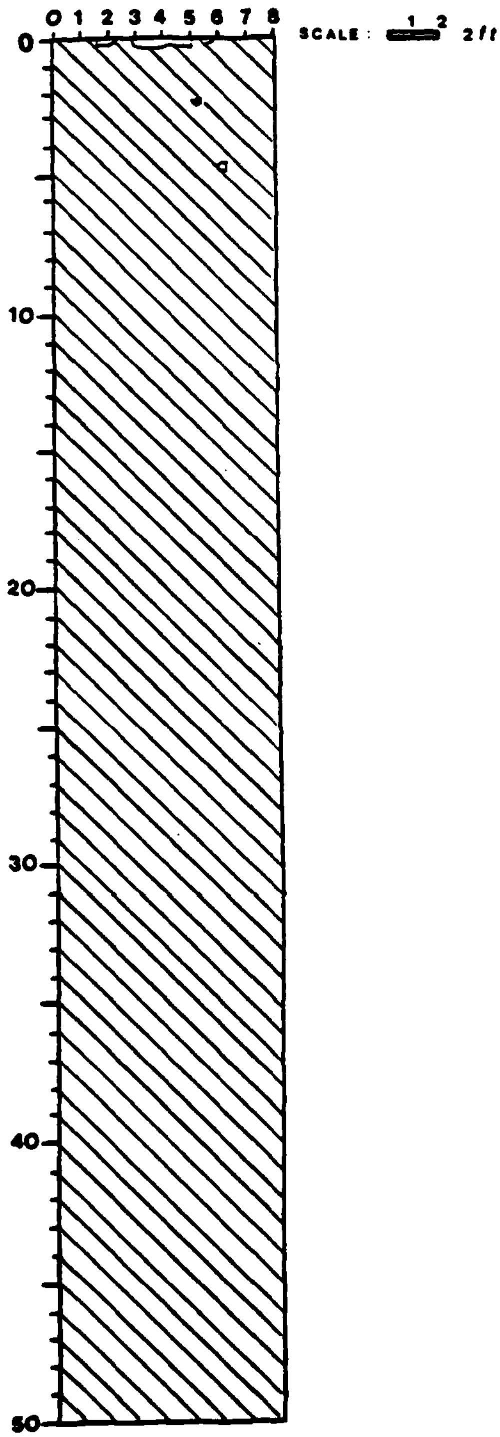


RIPRAP SIZE: .50 in

RUN NO: 16

DISCHARGE: 75 cfs

SLOPE: 56 x 10^{-5}

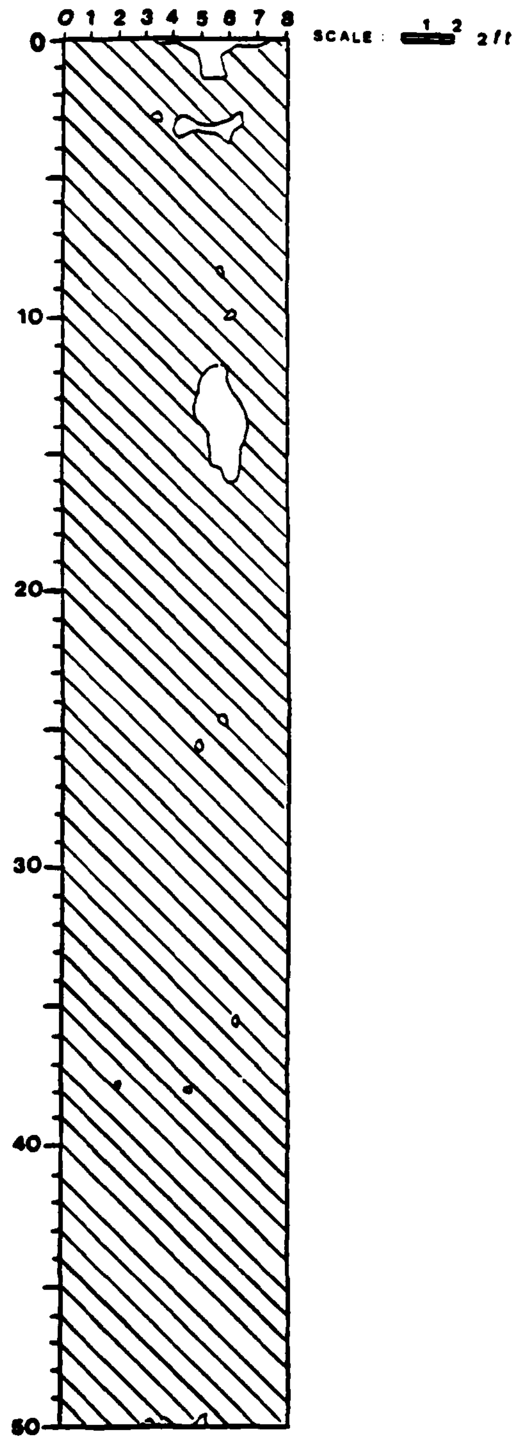


RIPRAP SIZE: .50 in

RUN NO: 17

DISCHARGE: 100 cfs

SLOPE: 56×10^{-5}

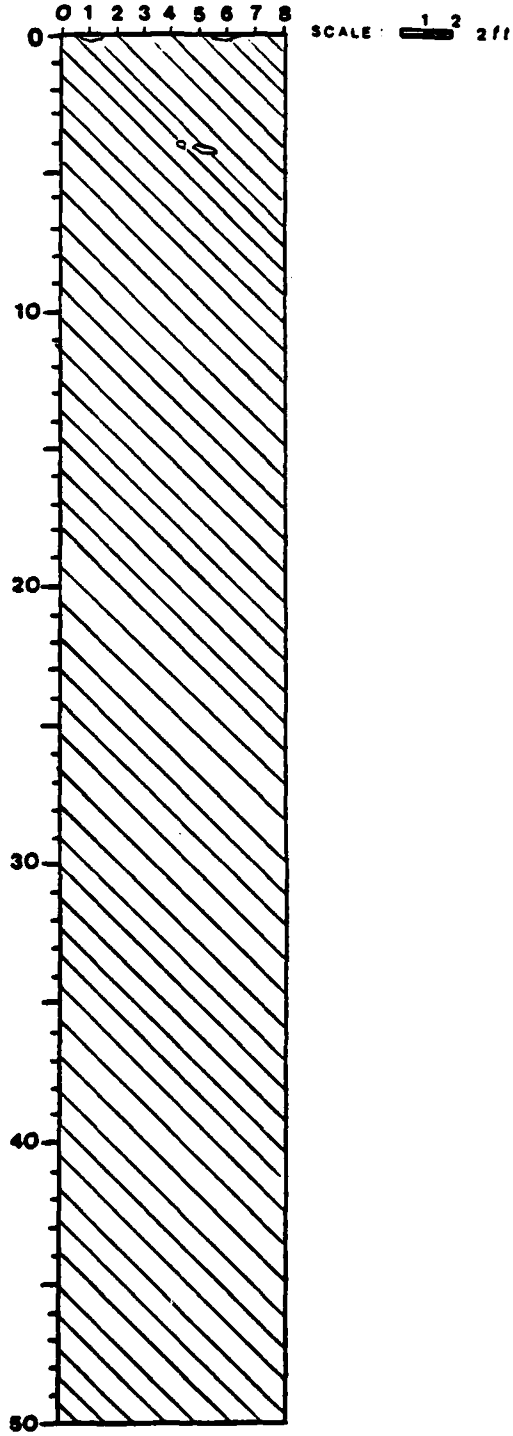


RIPRAP SIZE: 1.0 in

RUN NO: 1

DISCHARGE: 25 cfs

SLOPE: 348 $\times 10^{-5}$

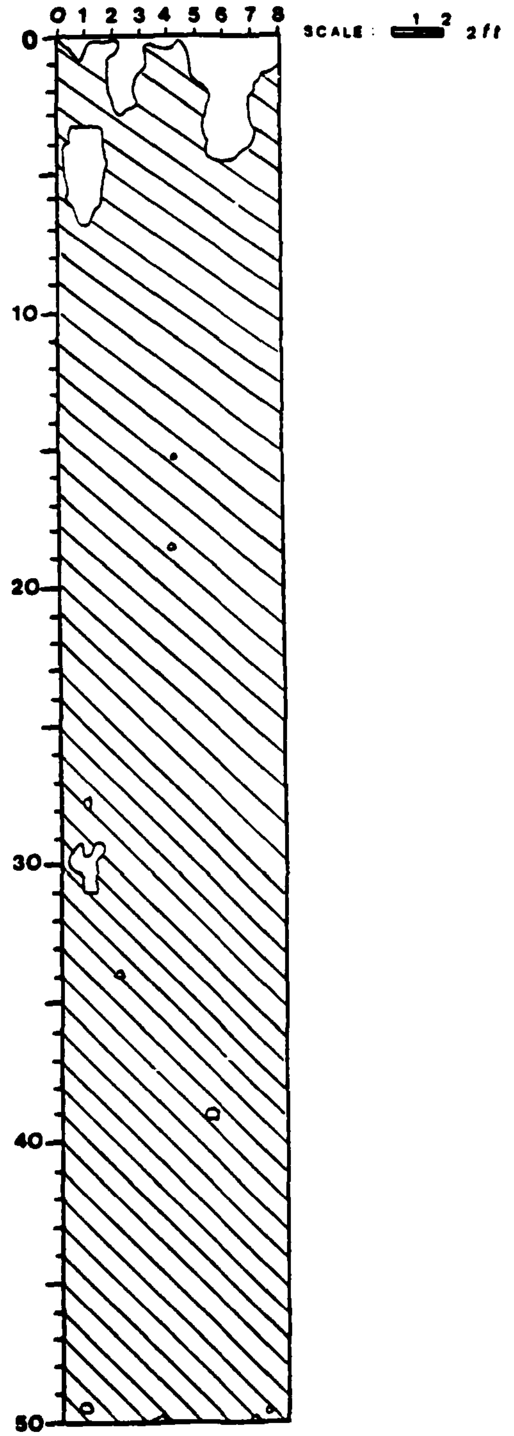


RIPRAP SIZE: 1.0 in

RUN NO: 4

DISCHARGE: 25 cfs

SLOPE: 562 x 10^{-5}

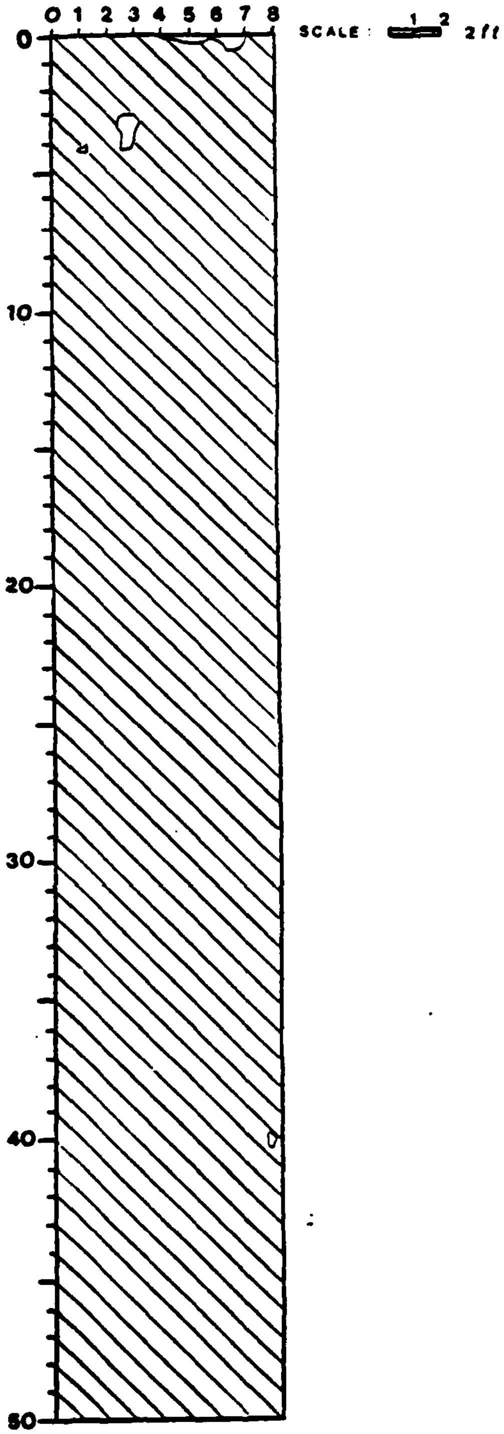


RIPRAP SIZE: 1.0 in

RUN NO: 5

DISCHARGE: 25 cfs

SLOPE: 451×10^{-5}

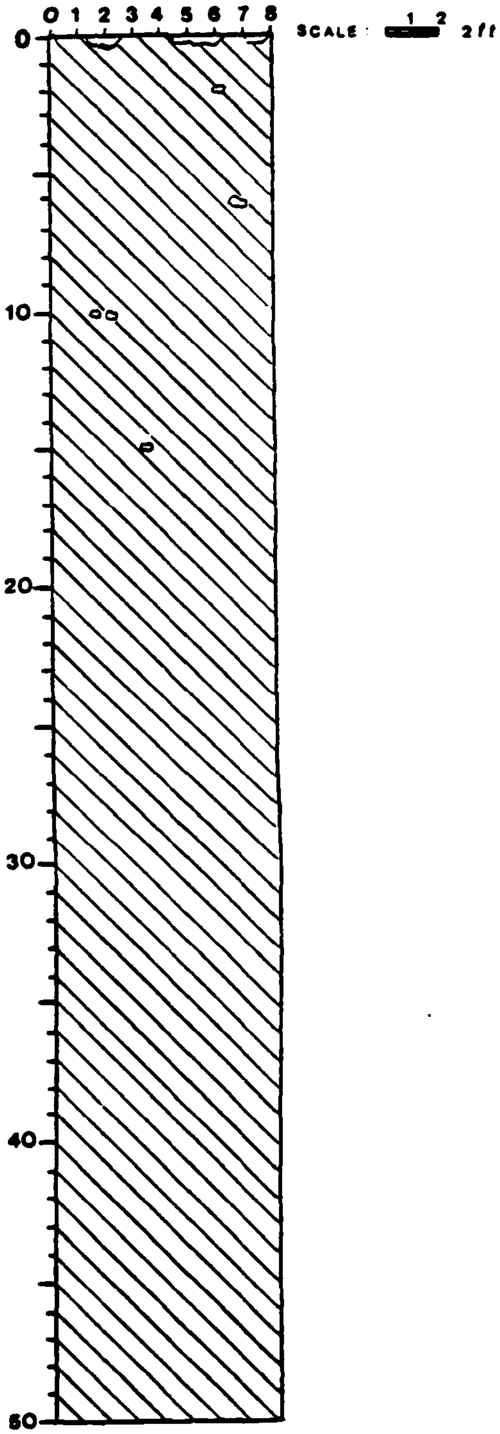


RIPRAP SIZE: 1.0 in

RUN NO: 6

DISCHARGE: 50 cfs

SLOPE: 249×10^{-5}

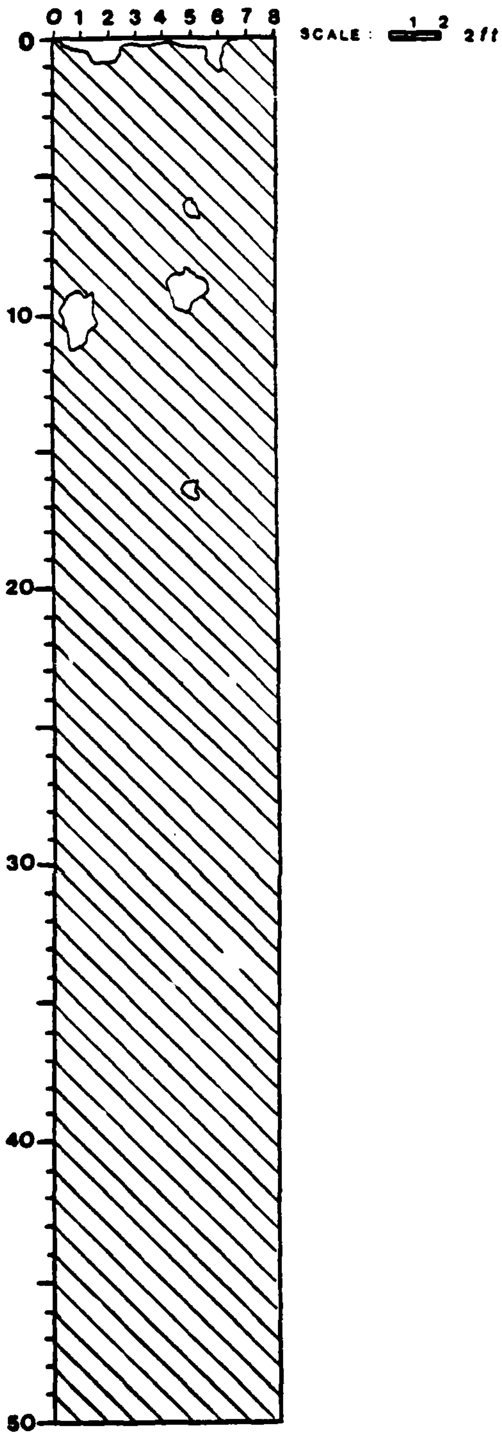


RIPRAP SIZE: 1.0 in

RUN NO: 7

DISCHARGE: 50 cfs

SLOPE: 310×10^{-5}

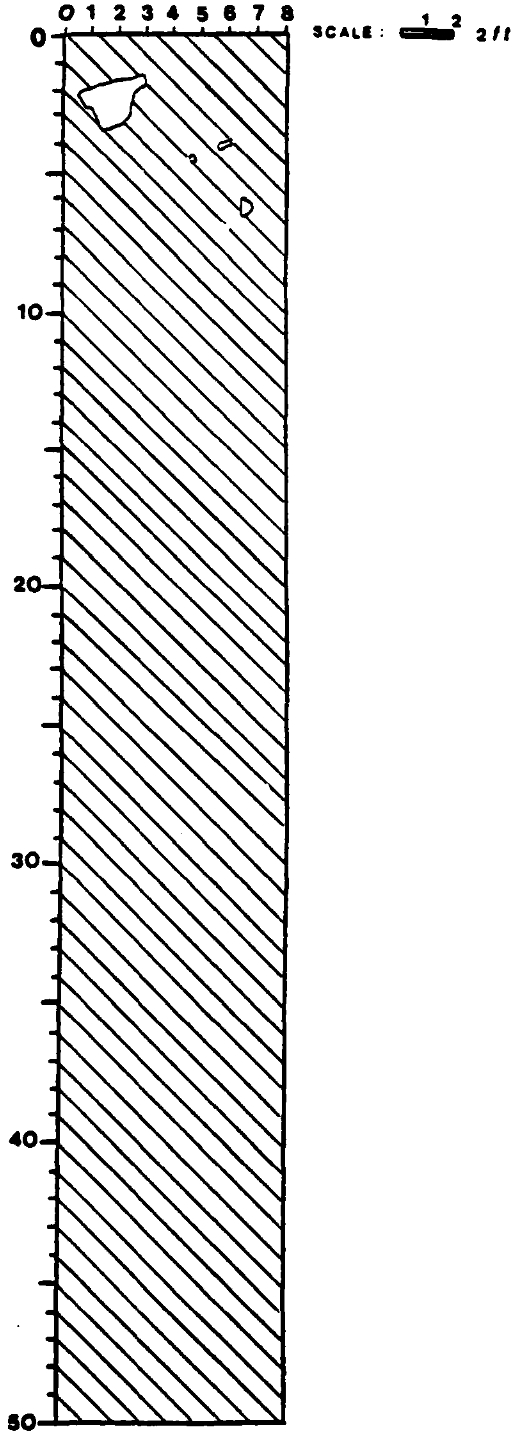


RIPRAP SIZE: 1.0 in

RUN NO: 8

DISCHARGE: 50 cfs

SLOPE: 249 x 10^{-5}

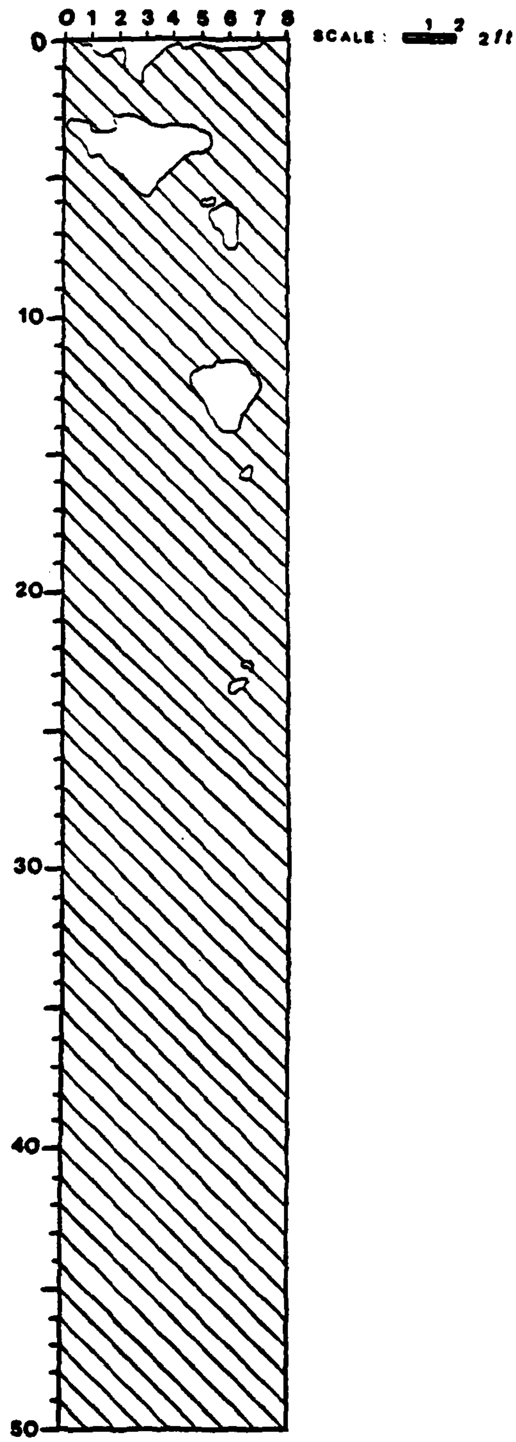


RIPRAP SIZE: 1.0 in

RUN NO: 9

DISCHARGE: 75 cfs

SLOPE: 176×10^{-5}

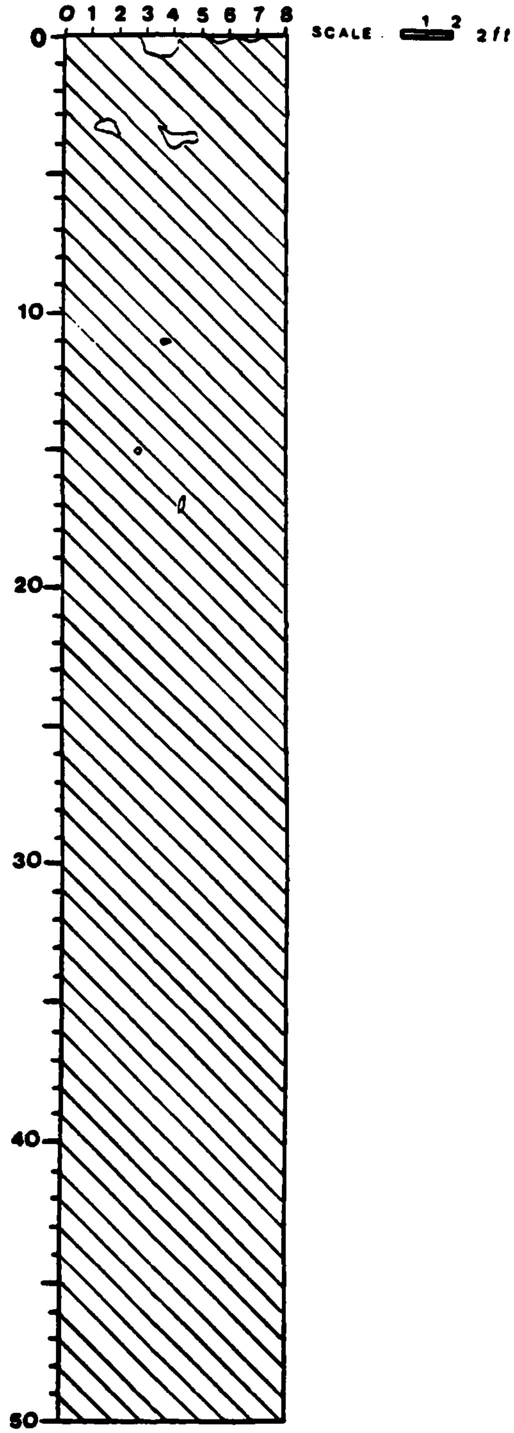


RIPRAP SIZE: 1.0 in

RUN NO: 10

DISCHARGE: 75 cfs

SLOPE: 176 $\times 10^{-5}$

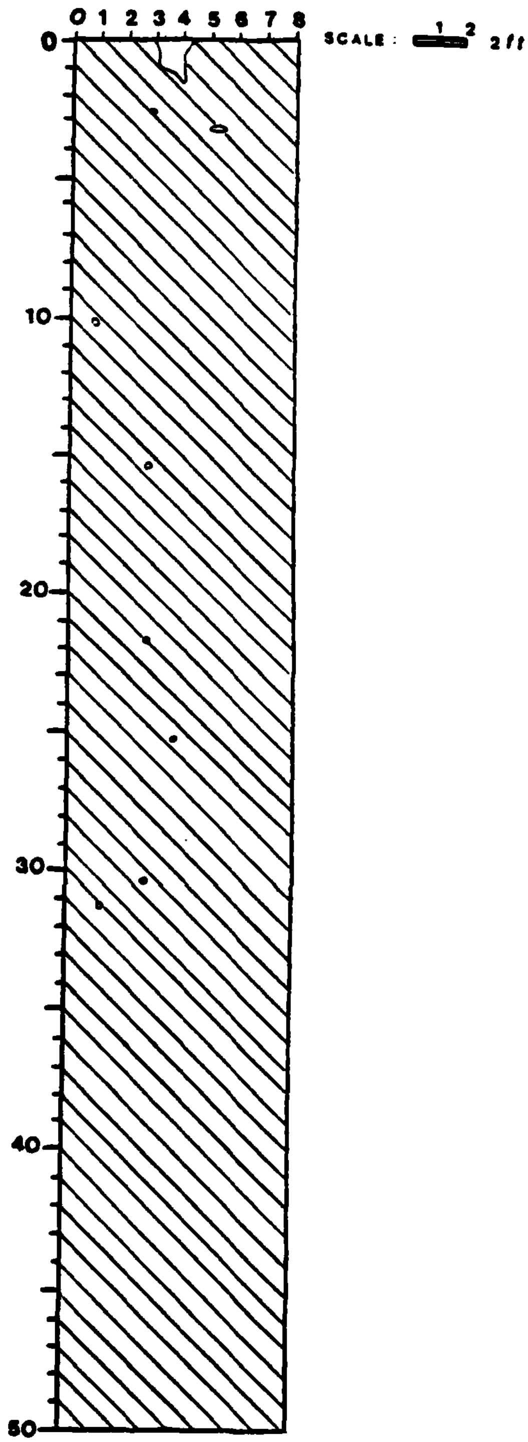


RIPRAP SIZE: 1.0 in

RUN NO: 11

DISCHARGE: 75 cfs

SLOPE: 219×10^{-5}

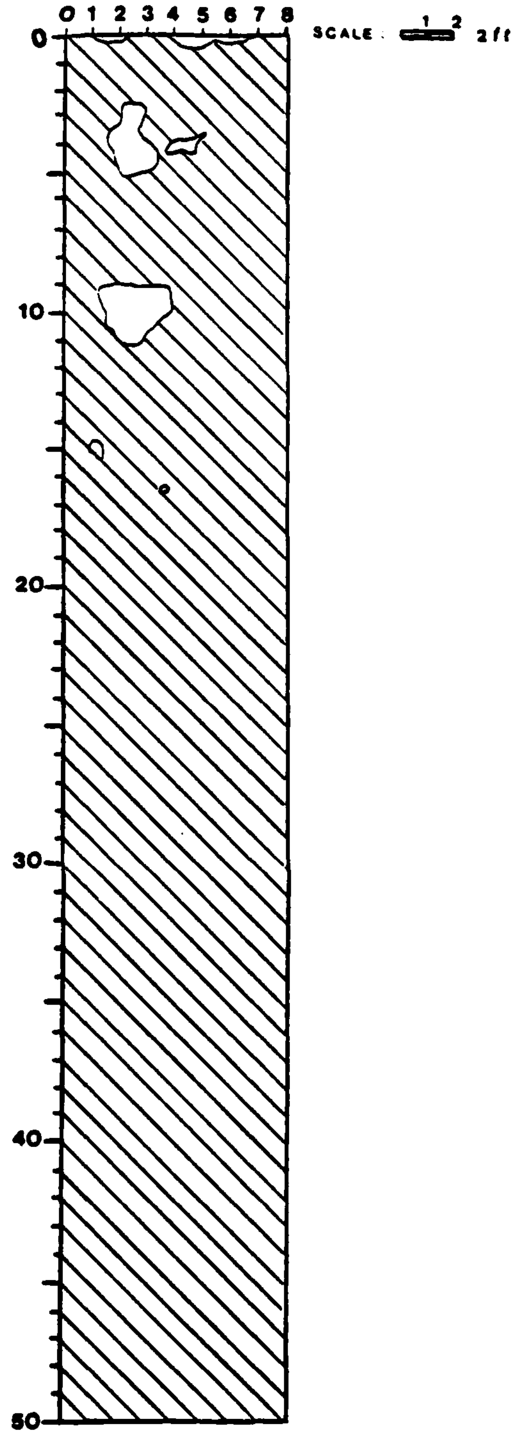


RIPRAP SIZE: 1.0 in

RUN NO: 12

DISCHARGE: 75 cfs

SLOPE: 265 $\times 10^{-5}$

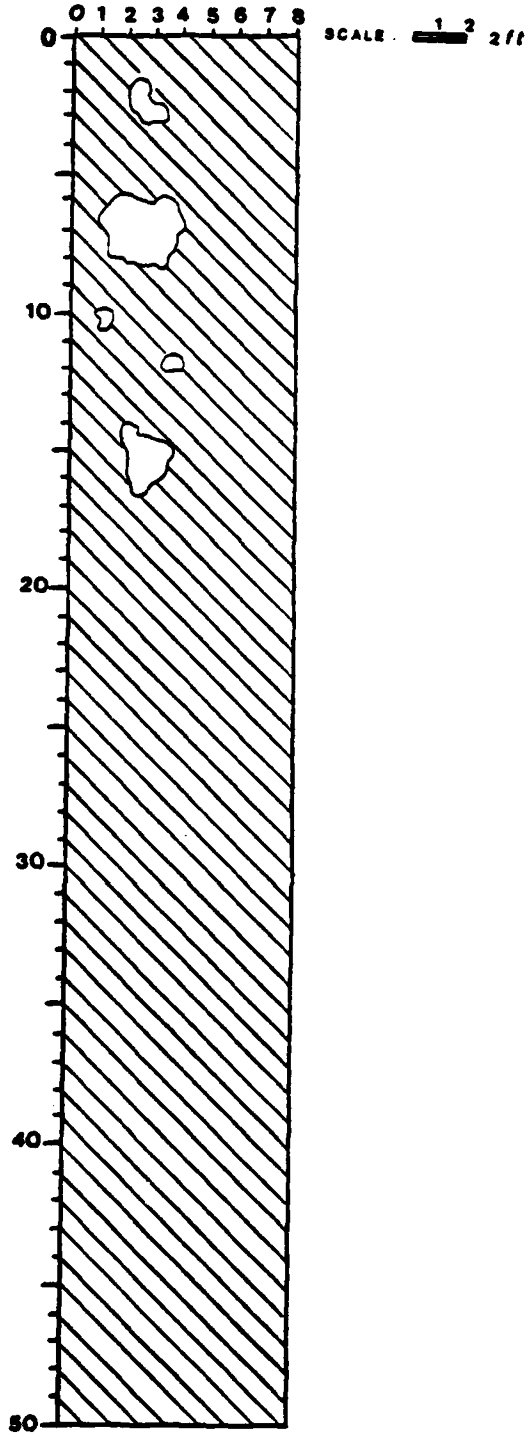


RIPRAP SIZE: 1.0 in

RUN NO: 13

DISCHARGE: 75 cfs

SLOPE: 219 $\times 10^{-5}$

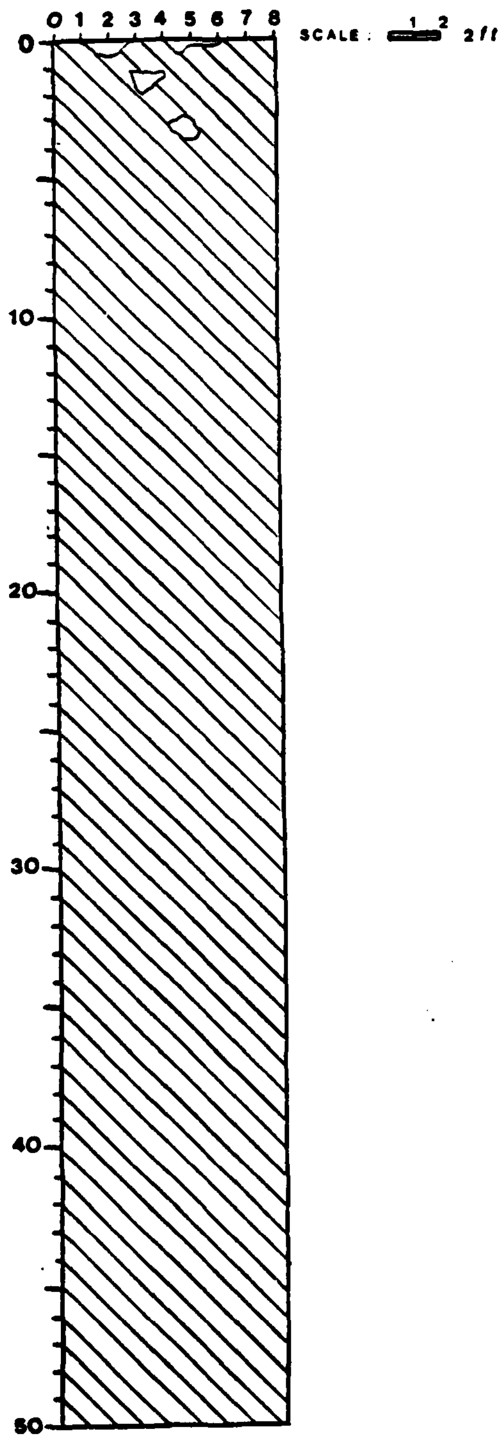


RIPRAP SIZE: 1.0 in

RUN NO: 14

DISCHARGE: 75 cfs

SLOPE: 176 $\times 10^{-5}$

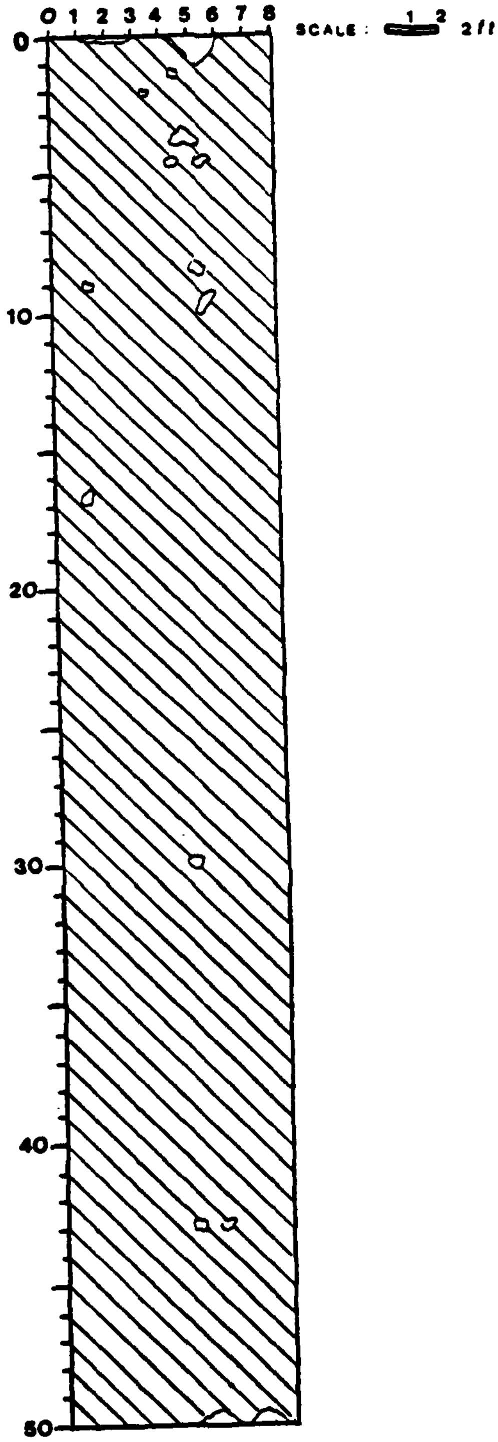


RIPRAP SIZE: 1.0 in

RUN NO: 15

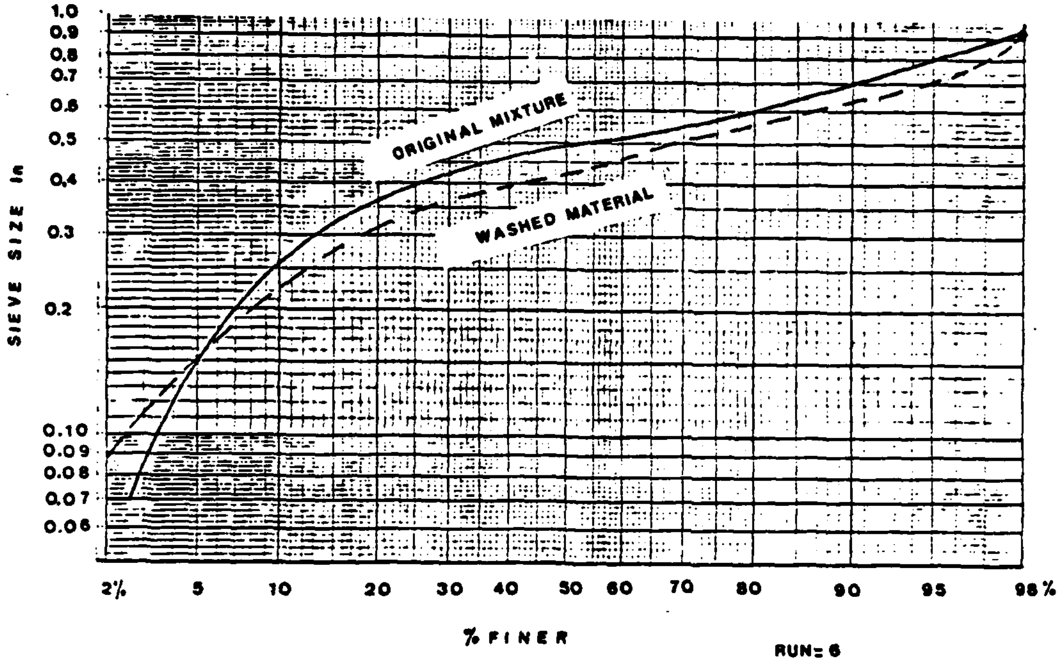
DISCHARGE: 100 cfs

SLOPE: 106×10^{-5}

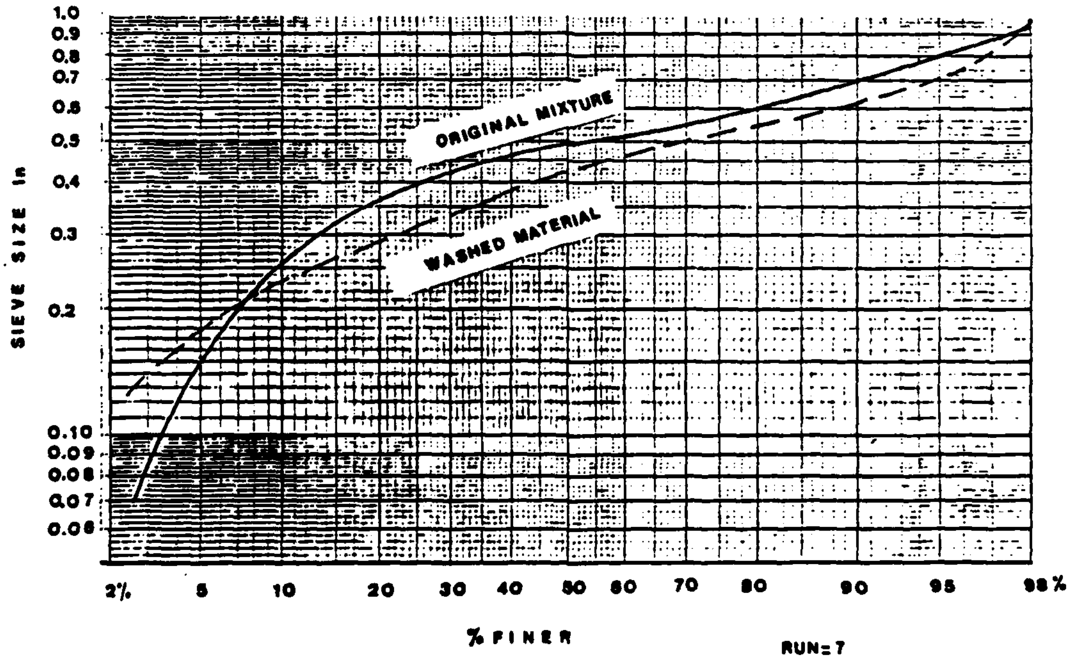


Appendix D

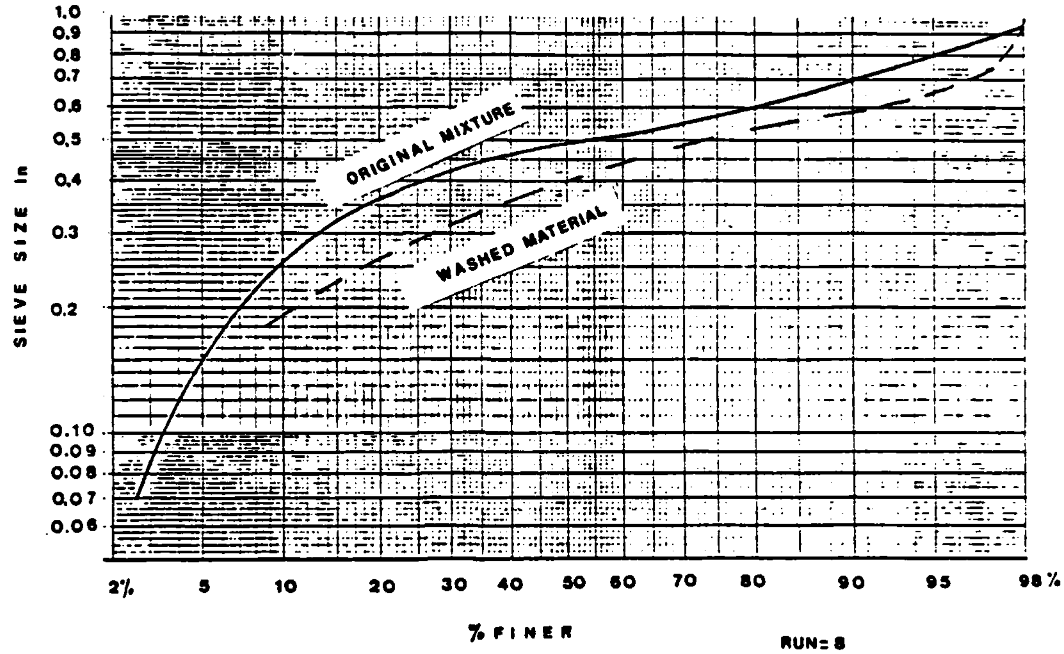
Analysis of Washed Sediment Sizes



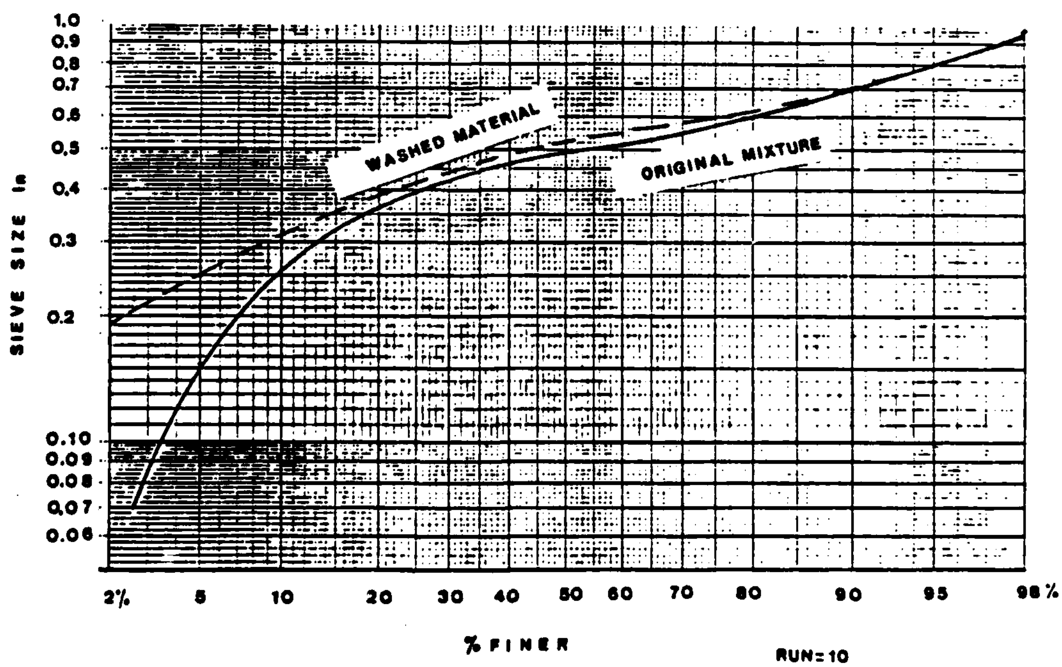
RUN= 6
S=0.00331
Q=25 cfs
d_{50}= 0.5 in



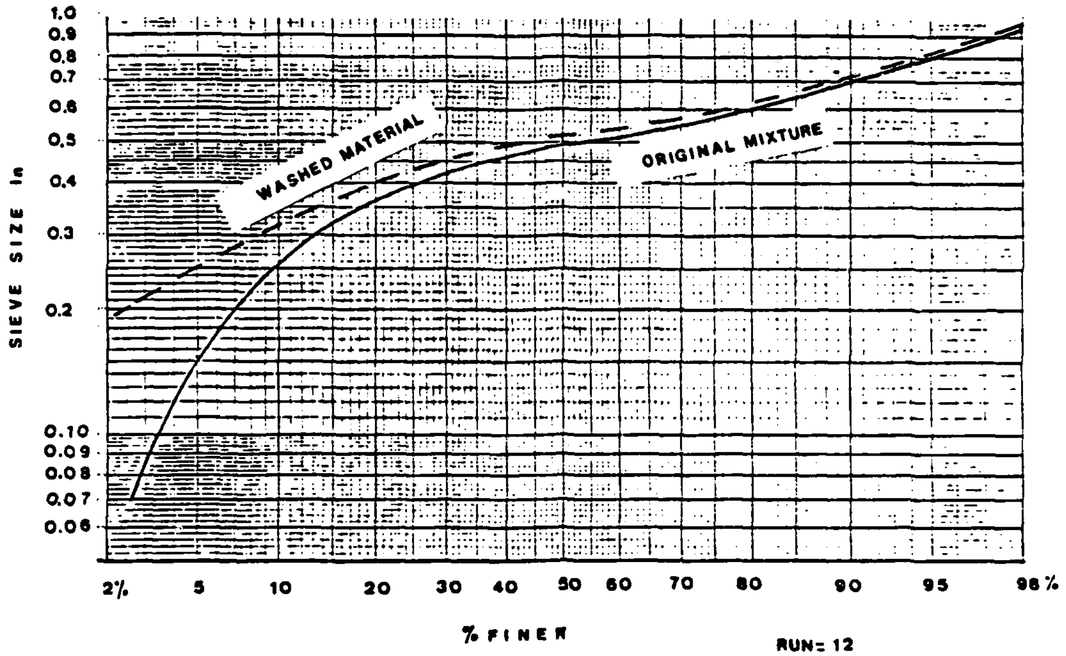
RUN= 7
S=0.00280
Q=25 cfs
d_{50}= 0.5 in



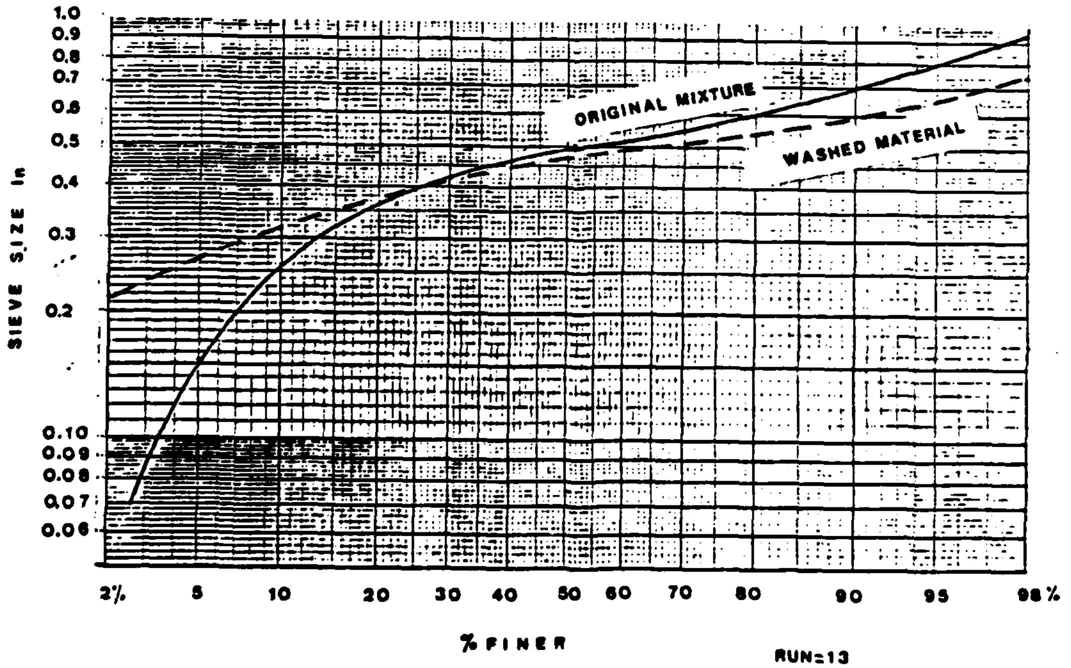
RUN= 8
S=0.00231
Q=25 cfs
d_{50}= 0.5 in



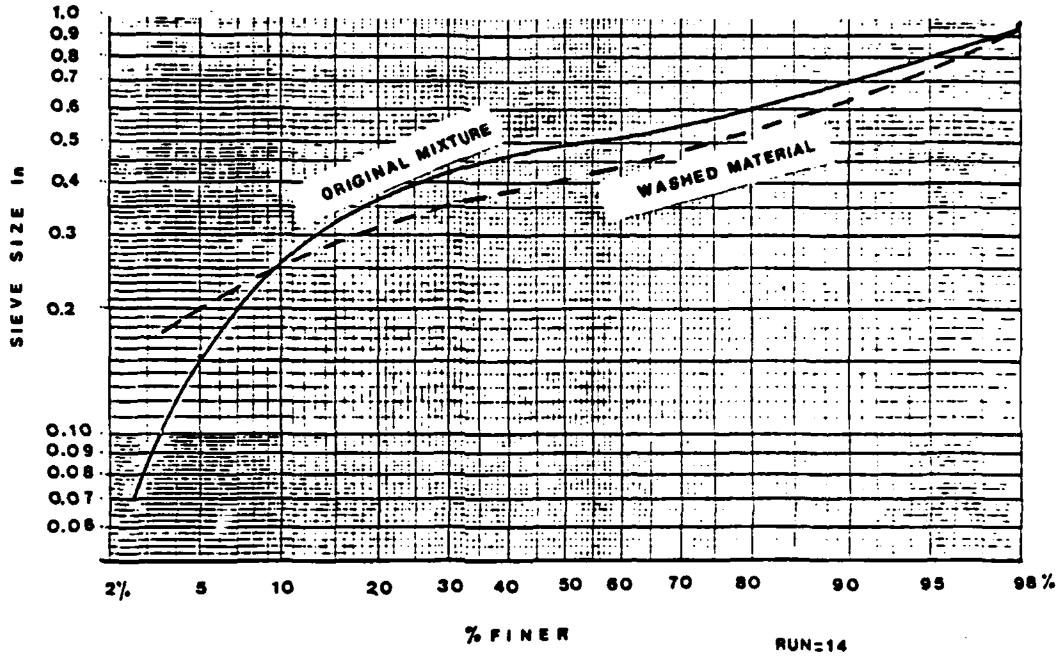
RUN= 10
S=0.00128
Q=50 cfs
d_{50}= 0.5 in



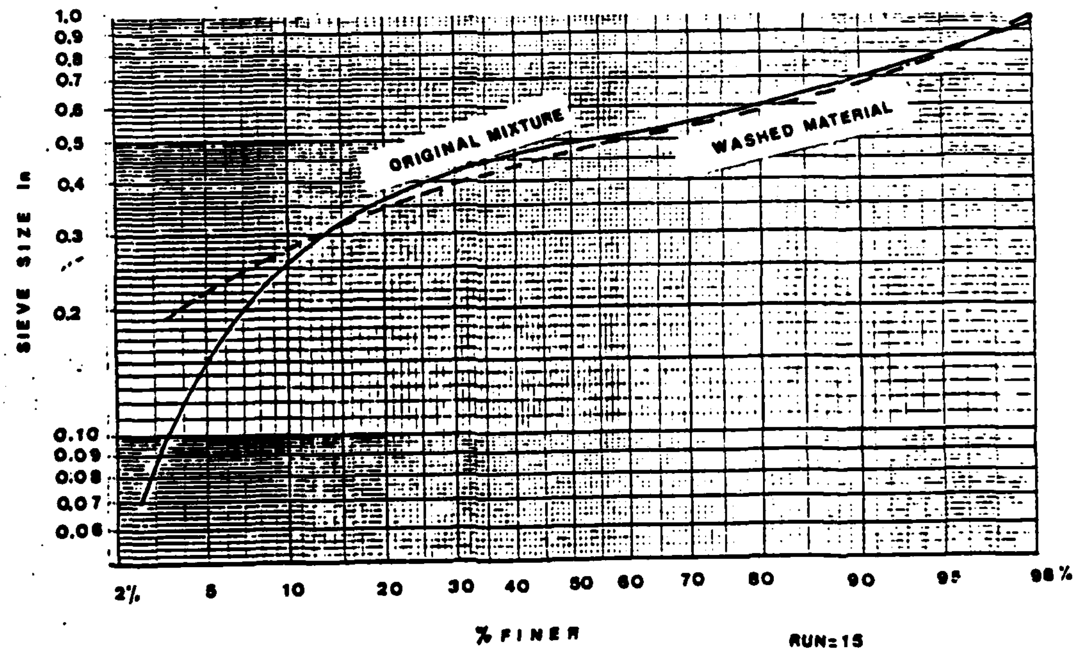
RUN= 12
S=0.00102
Q=50 cfs
d_{50}= 0.5 in



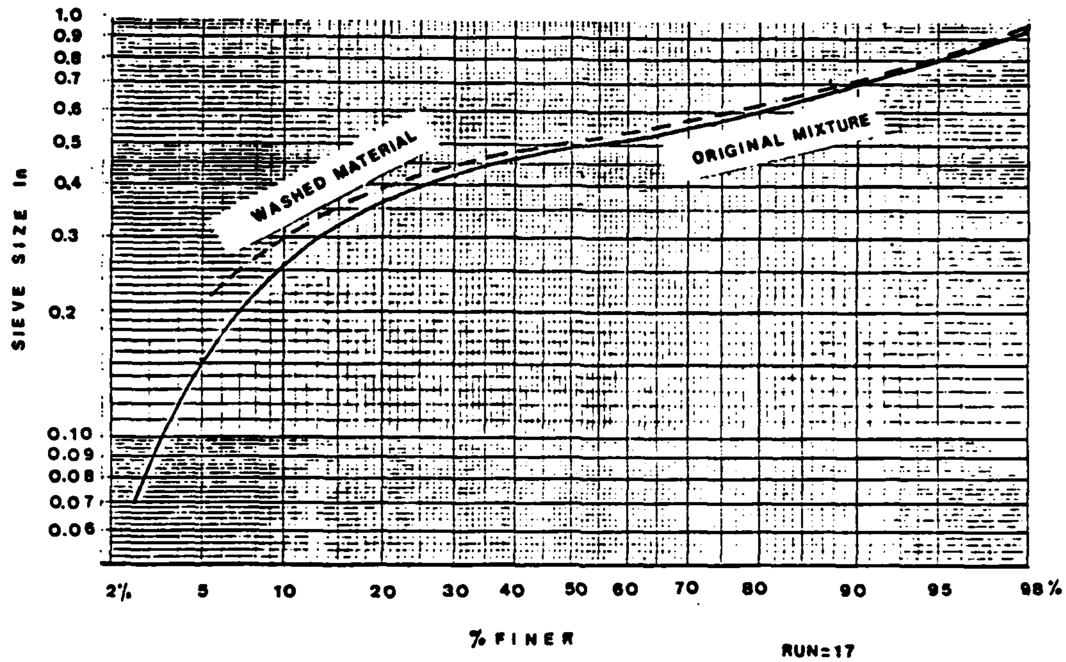
RUN=13
S=0.00072
Q=75 cfs
d_{50}= 0.5 in



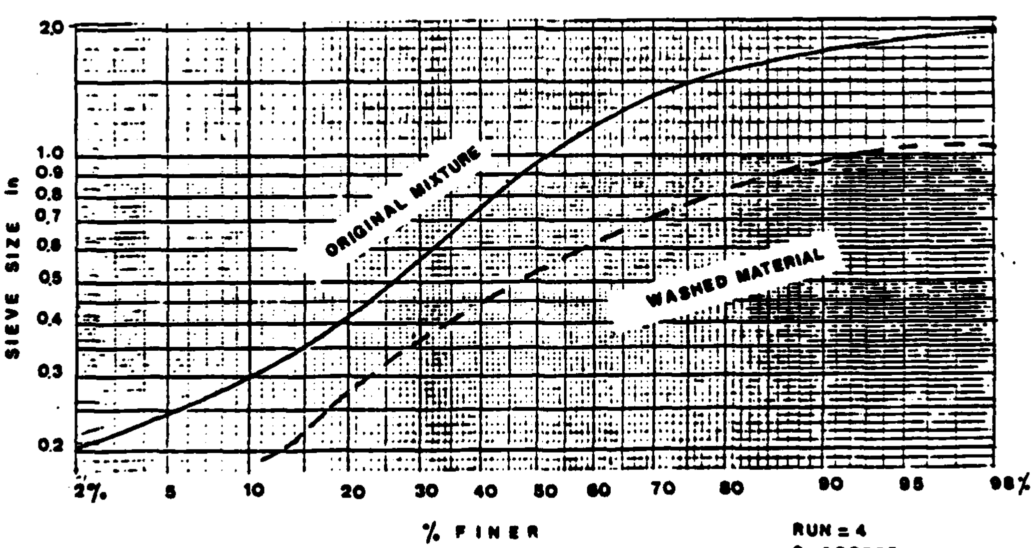
RUN=14
S=0.00090
Q=75 CfS
d_{50}= 0.5 in



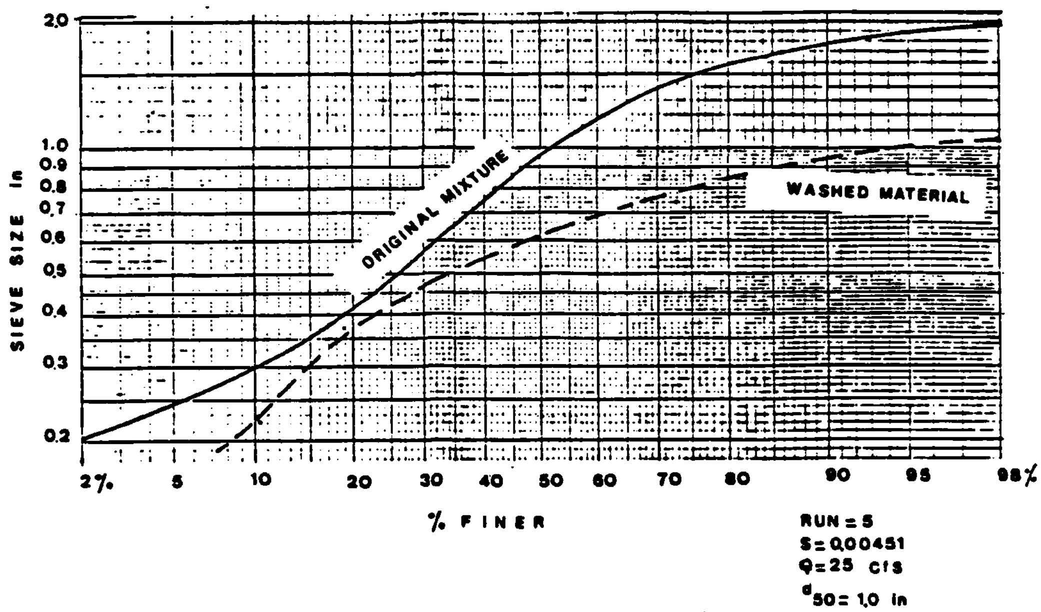
RUN=15
S=0.00072
Q=75 CfS
d_{50}= 0.5 in

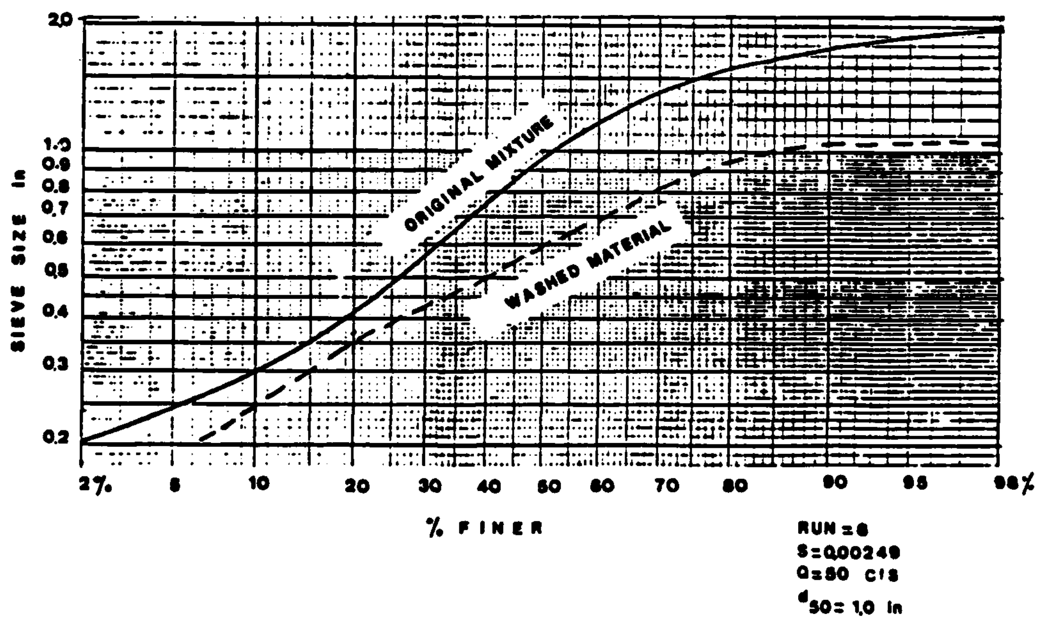


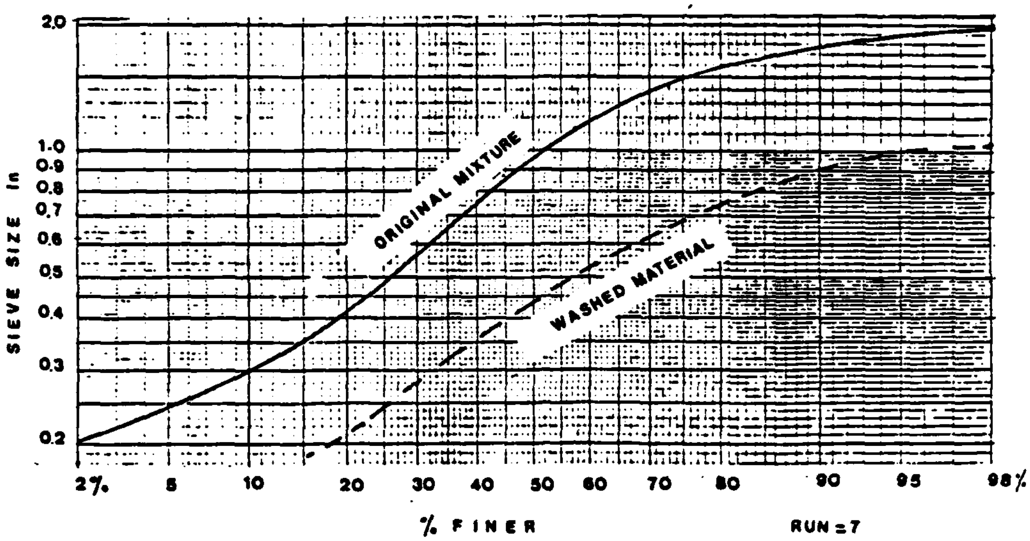
RUN=17
S=0.00056
Q=100 cfs
d_{50}= 0.5 in



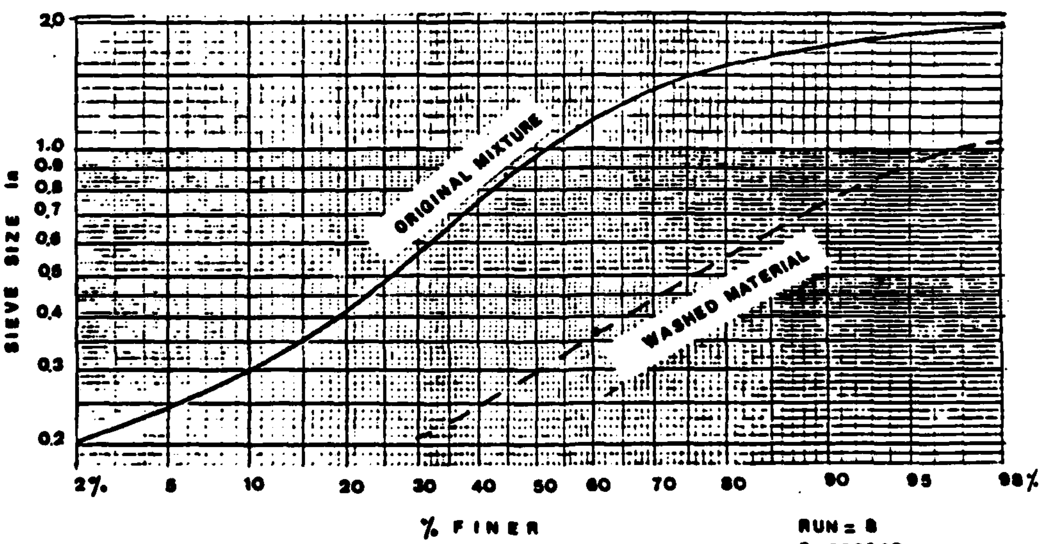
RUN = 4
S=0.00562
Q=25 cfs
d_{50}= 1.0 in


2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
SIEVE SIZE in
ORIGINAL MIXTURE
WASHED MATERIAL
2% 5 10 20 30 40 50 60 70 80 90 95 98%
% FINER
RUN = 5
S = 0.00451
Q = 25 cfs
d50 = 1.0 in

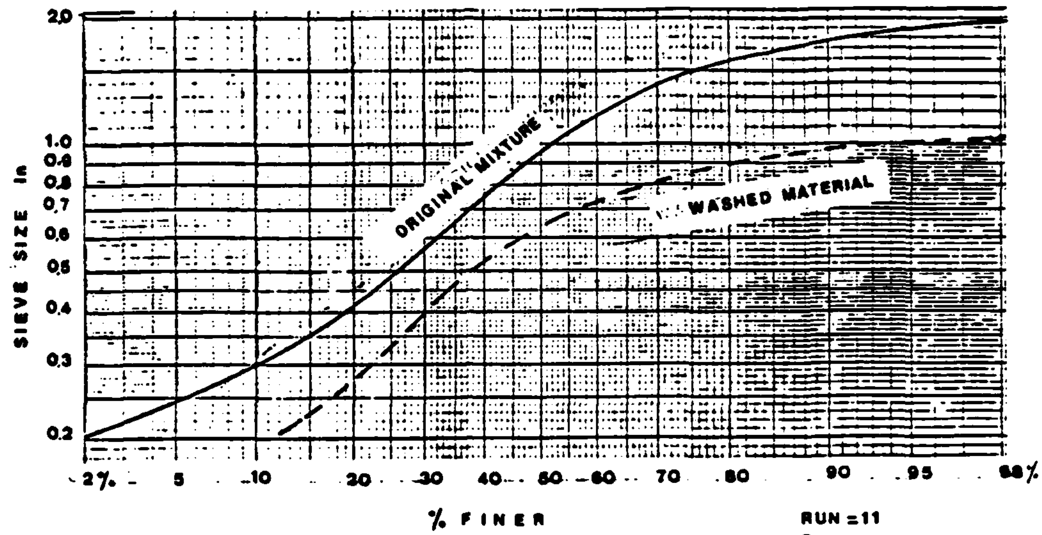

2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
SIEVE SIZE in
ORIGINAL MIXTURE
WASHED MATERIAL
2% 5 10 20 30 40 50 60 70 80 90 95 98%
% FINER
RUN = 6
S = 0.00249
Q = 50 cfs
d50 = 1.0 in



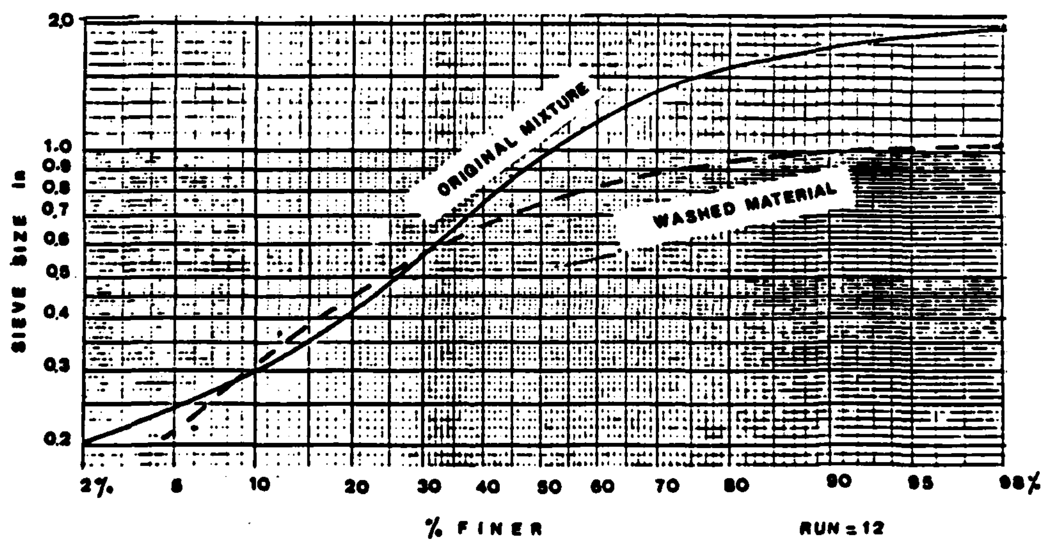
RUN = 7
S = 0.00310
Q = 50 cfs
d_{50} = 1.0 in



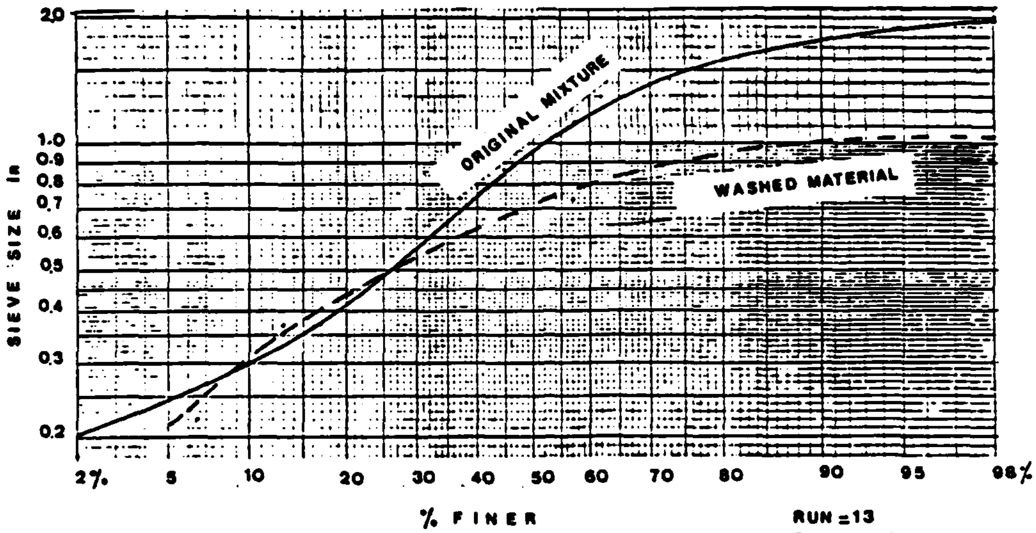
RUN = 8
S = 0.00249
Q = 50 cfs
d_{50} = 1.0 in



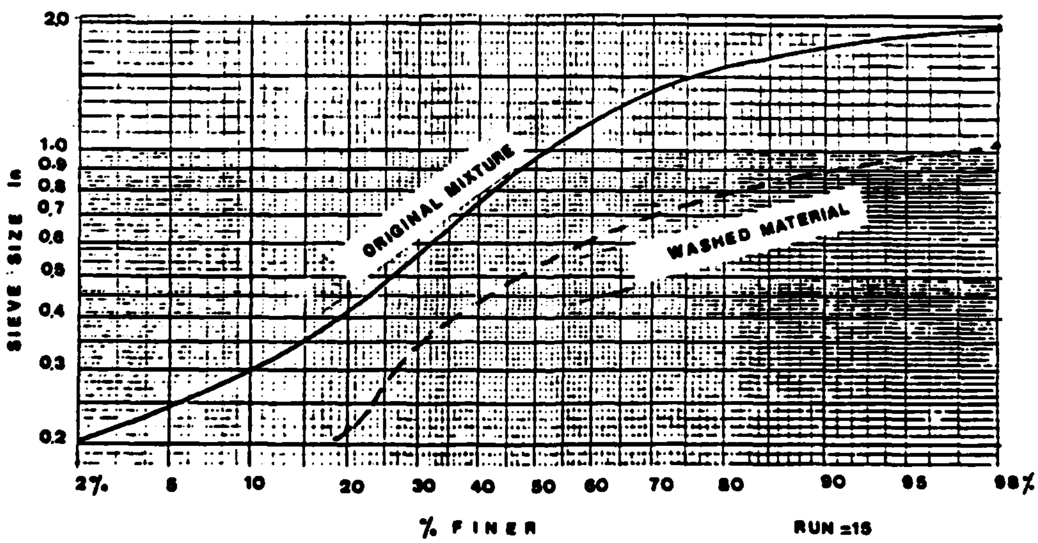
RUN = 11
S = 0.00219
Q = 75 cfs
d_{50} = 1.0 in



RUN = 12
S = 0.00268
Q = 75 cfs
d_{50} = 1.0 in



RUN =13
S=0.00219
Q=75 cfs
d_{50}= 1.0 in



RUN =15
S=0.00106
Q= 100 cfs
d_{50}= 1.0 in

1985 RIPRAP TESTS
IN FLOOD CONTROL CHANNELS

prepared for

U. S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, Mississippi

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FORWARD

This study was performed under a contract titled "Stability Tests of Riprap in Flood Control Channels" between the U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, and Colorado State University. This report includes the tabluated and mapped data collected during the study, as well as analysis of the major results. The study plan and program was coordinated between WES and CSU by Mr. Stephen T. Maynard of WES.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background

This study is a continuation of the work to determine the point of incipient failure and other hydraulic characteristics of riprap for providing criteria for design of stable ripraps in flood control channels. The study initiated in 1981 at Colorado State University (CSU) by and in cooperation with the U. S. Army Corps of Engineers, Waterways Experiment Station (WES), Vicksburg, Mississippi. The previous work was presented in two reports. The first report entitled, "Stability Tests of Riprap in Flood Control Channels," was prepared by A. A. Fiuzat, Y. H. Chen and D. B. Simons in October, 1982, and is referred to as the "1982 Report" throughout this latest report (1985). The second report was entitled, "Supplemental Stability Tests of Riprap in Flood Control Channels" and was prepared by A. A. Fiuzat and E. V. Richardson in December, 1983. The second report similarly is referred to as the "1983 Report" throughout this new report (1985). The equipment, flume test procedures, and data collection methods are either identical or similar to those procedures described in the 1982 and 1983 Reports.

Two sizes riprap materials were tested. One material had a d_{50} = 1.0 in. and the other had a d_{50} = 2.0 in. Both riprap sizes had the ETL 1110-2-120 gradation recommended by WES. The design gradation of the riprap material is

shown in Figure 1.1. The design gradation of the riprap material of the 1982 and 1983 Reports is also shown in this Figure. Tests were performed for both size gradations with the thickness of the riprap set at $2d_{50}$ and then at $3d_{50}$. The failure criterion for both riprap thicknesses was the exposure of the underlying filter blanket observed after a run. Incipient failure was then defined as the run when the flume slope was set one increment lower than the failure run. In the following chapters the experimental program and analysis of data are presented.

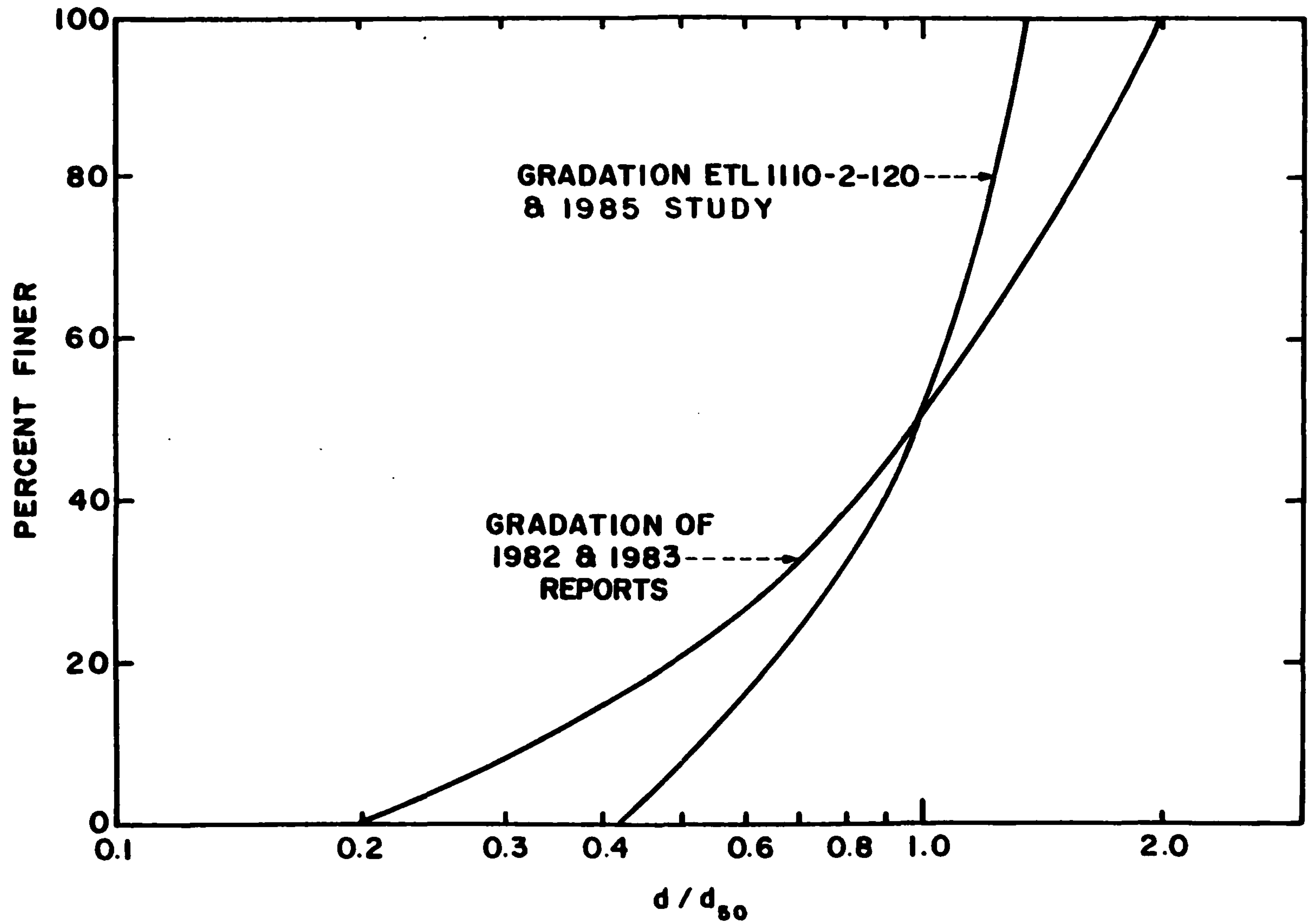

Figure 1.1 Gradation of riprap material of this study (1985) and the 1982 and 1983 Reports.

CHAPTER 2

EXPERIMENTAL PROGRAM

The experimental program conducted for this phase of the riprap study generally follows the procedures and methods described in the 1982 and 1983 Reports.

In this chapter the materials and methods that differ from those of the 1982 and 1983 Reports are explained. Those which are not explained are similar to the 1982 and 1983 Reports.

2.1 Experimental Setup

For the first 18 runs, the test section was 50 ft long with a transition section of 40 ft. From the upstream end of the flume (Station 0) to the beginning of the transition section (Station 60), rocks of 6 to 10 in. in diameter were cemented to the flume floor. The 40 ft transition section (from Station 60 to station 100) was made of 1 in. rocks cemented to the flume floor. For the remaining runs (from run #19 to 94), the test section was reduced to 40 ft and the transition section was constructed by placing rocks of similar size as the test section in the transition. These rocks in the transition section were not cemented to the flume floor; instead they were covered with a wire mesh (chicken wire) to hold them in place. The transition section was 40 ft long and started at Station 70. The test section started at Station 110. The rocks in the transition section were placed such that the top of the rocks in the test and transition sections were in the same plane for all riprap thicknesses. The first 70 ft of the flume was comprised of 6 to 10 in. rocks cemented on the floor.

2.2 Material

Crushed limestone was used as the riprap material. The specific gravity of the d_{50} = 1 in. rocks was 2.68 and the d_{50} = 2 in. rocks was 2.64. The gradations of the riprap material tested are shown in Figure 2.1. The gradation of d_{50} = 1 in. riprap was determined using a mechanical sieve shaker. The gradation of d_{50} = 2 in. riprap was established using flat sieves manufactured at CSU for this purpose. The values of d_{85}/d_{15} of the riprap material are presented in Table 2.1. In this Table the values of d_{85}/d_{15} of the riprap material of the 1982 Report (for d_{50} = 1 in) and the 1983 Report (for d_{50} = 2 in) are also presented.

Table 2.1 Values of the d_{85}/d_{15} of the riprap material of this (1985) Study and the 1982 and 1983 Reports.

	This Study (1985)		1982 Report	1983 Report
d_{50} (in)	1	2	1.87	1
d_{85}/d_{15} (in)	2.0	2.4	2.8	4.4

For the first series of tests (d_{50} = 1 in., runs # 1- 31) the riprap material consisted of about 10 percent (by weight) flat rocks. The flat rocks were removed after the first series of tests. For the rest of the runs, the riprap material met the shape criteria of the Army Corps of Engineers. These criteria (C.O.E. Report - Em 1110-2-1601, 1970) are:

1. The stone shall be predominately angular in shape.
2. No more than 25 percent of the stones reasonably well distributed throughout the gradation shall have a length more than 2.5 times the breadth or thickness.
3. No stone shall have a length exceeding 3.0 times its breadth or thickness.

2.3 Testing Procedure and Data Collection Program

The data collected included bed and water surface elevations, discharge, velocity profiles using either a pitot-static tube or an Ott meter, and the size and location of areas washed free of riprap down to the underlying filter cloth. Trials were performed with riprap thickness of $2d_{50}$ and $3d_{50}$.

A "general datum" for each rock thickness was established by the following procedures:

(1) The flume was set to the horizontal position.

(2) Water was added to the flume until about 90% of the rocks were covered with water.

(3) The elevation of the water surface was measured along the flume at 10 ft intervals; at the locations where flow depths were measured.

(4) These elevations were considered as the elevations of the bottom of channel (general datum) in measuring the flow depth.

Five series of tests with a total of 94 runs were performed. The methods of testing are summarized in Table 2.2. Other information such as bed slope, water temperature, area washed, and test duration for each run are presented in Appendix A.

Table 2.2 Methods of Testing

Test Series #	Run #	Median Size (in) (in)	Riprap Thickness	Velocity Data Collected By	Remarks
1	1-31	1	2	Ott Meter	Data collection was similar to the previous reports.
2	32-45	1	2	Ott Meter	Repeating the series #1 after removing flat rocks.
3	46-64	1	3	Pitot Tube	Flat rocks were removed.
4	65-78	2	4	Pitot Tube	Flat rocks were removed.
5	79-94	2	6	Pitot Tube	Flat rocks were removed.

As shown in Table 2.2, the test procedure for the riprap of d_{50} = 1 in. and thickness = 2 in. was similar to that of the 1982 and 1983 Reports. For test series No. 3 to 5, a pitot tube was used to measure the velocities. For these last series of tests the velocity data were collected at 0.05, 0.10, 0.15, 0.2, 0.3, 0.4, 0.5, 0.7, 0.9D above the "general datum." In addition, the pitot tube was set on the top of the rocks and velocities at these points also were measured. These points established by the pitot tube on top of the rocks will be referred as the "local datums." The elevations of these local datums in most cases were below the general datum. For the last 3 series of tests the comprehensive velocity data were collected for every test, and not only for the incipient failure conditions. Velocity profile traverses were taken at several locations in the cross sections throughout the test section. Specific locations are listed for each run in Appendix B.

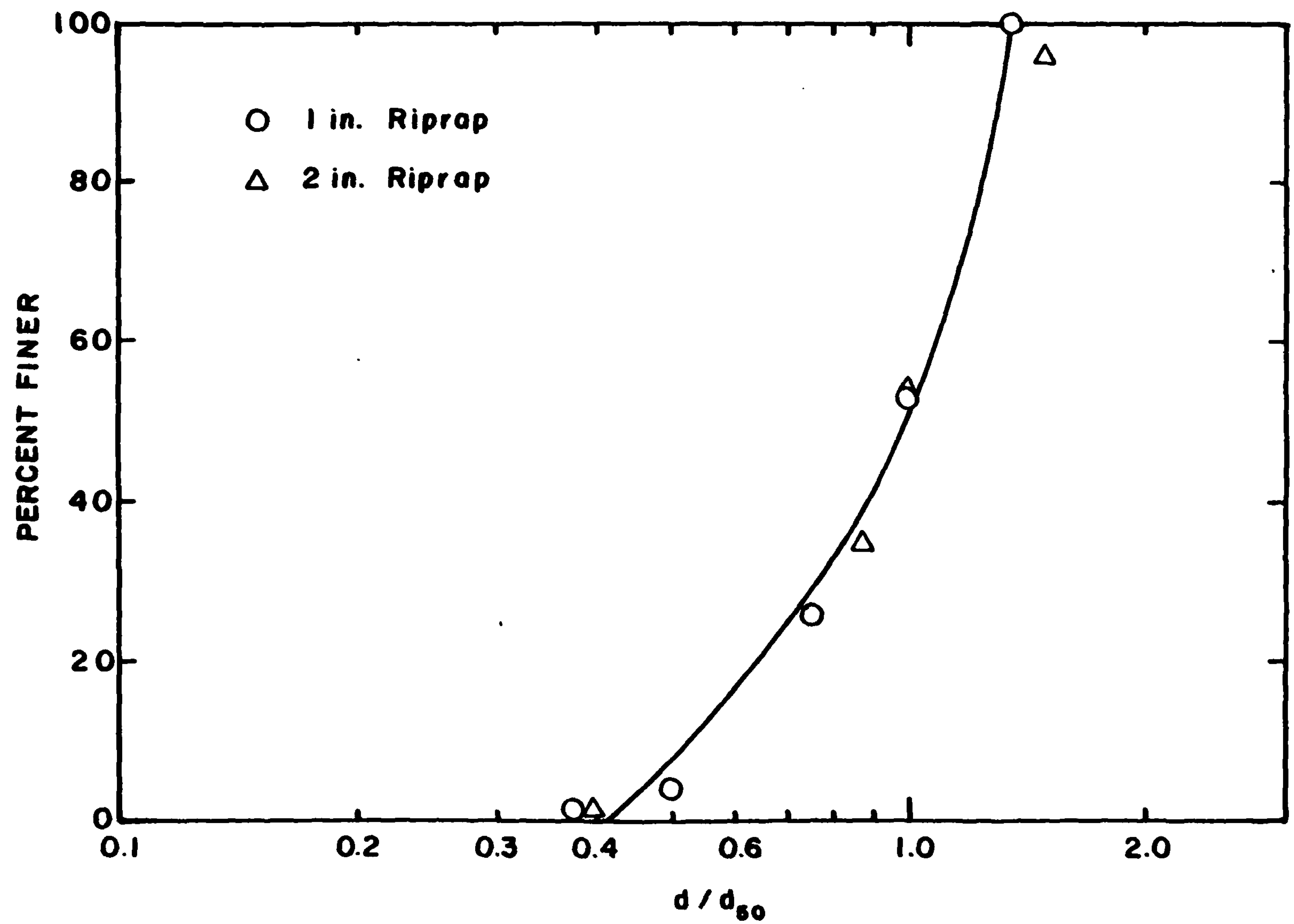

Figure 2.1 Gradation of riprap material tested.

CHAPTER 3

DATA ANALYSIS

The failure criterion for the riprap stability study was the exposure of the underlying filter blanket after a run. For a given discharge, the run at which the flume slope was one increment lower than the failure run was regarded as the incipient failure run. In this study the term "incipient failure" was used in place of "incipient motion" to avoid confusion. Incipient motion condition is considered to occur when the exerted force by flow just overcomes the resistance force of a particle to motion without moving the particle. However, at the incipient failure condition, a substantial amount of riprap material may move without exposing the underlying filter blanket. The latter condition can occur specially at greater thicknesses of ripraps.

In this study there were some exceptional cases where the above criterion was not met. These cases are explained in the following.

The transition section for the first 18 runs was made of 1 in. rocks cemented to the flume floor, as previously mentioned. The transition section was 40 ft. long; the elevation of upstream end was 8 in. above the elevation of downstream end with a slope of 1.7 percent relative to the flume floor. The flow accelerated down this slope and did not produce a smooth transition into the test section. Because of this transition section, it was not possible to reach uniform flow depth within the test reach at discharge greater than 25 cfs, and all riprap failure occurred at the beginning of the test section due to high velocity of flow. The test result was not considered to be representative of behavior of the riprap under uniform flow for flows greater than 25 cfs because of the problems caused by the transition section.

Therefore, the transition section was reconstructed and the tests were repeated. Since the above problems were not pronounced for the flow rate of 25 cfs, the tests were not repeated for the 25 cfs flow rate. The data for runs 8 to 18 were not used for analysis in this chapter, however, they are presented in Appendices.

In run numbers 27, 37, 41 and 45 the failure occured at the beginning of the test section and was believed to be the result of local disturbances at the junction between the transition and test section. These runs were not considered to be the failure runs but the incipient failure runs. The washed area for these runs was less than three square feet which occurred at the beginning of the test section.

For run #77 (d_{50} = 2 in, $2d_{50}$ thick riprap) failure was not observed when the flow rate was 25 cfs and flume was at its maximum slope (about 1.9 percent). When the riprap thickness was increased to $3d_{50}$, failure did not occur at flows equal to or less than 50 cfs and maximum flume slope (run #s 80 and 84). Run #84 was, however, considered to be the incipient failure run since some of the rocks were moved and several dips were observed on the riprap surface.

The following methods are used to calculate the bed Shields' coefficients from the collected data.

1) Using Manning's roughness factor for riprap surface
2) Using Darcy-Weisbach friction factor for riprap surface
3) Using velocity distribution equation

3.1 Calculation of Bed Shields' Coefficient Using Manning's Roughness Factor For Riprap Surface

The development of the equations to calculate the Manning's roughness factor for the riprap surface n_b is presented in the 1982 Report (p. 19). This method is a side-wall correction technique (Vanoni, 1975, P. 152) which can be used to calculate

the average shear stress on the bed, τ_b, and bed Shield's coefficient C_b. The assumptions in this technique are: a) the flow cross-sectional area can be divided into two parts, A_b and A_w where resistance to flow is caused by the bed and the walls respectively, and b) the mean velocity and energy gradient are the same for A_b and A_w and Manning's equation can be applied to each part of the cross-section as well as to the whole. The resulting equations (developed in the 1982 Report) for this technique are:

$$n = \frac{1.49}{V} R^{2/3} S^{1/2} \tag{3.1}$$

$$\frac{R}{n^{3/2}} = \frac{R_b}{n_b^{3/2}} = \frac{R_w}{n_w^{3/2}} \tag{3.2}$$

$$n_b = \left[\frac{n^{3/2} p - n_w^{3/2} \cdot p_w}{p_b}\right]^{2/3} \tag{3.3}$$

where

n, n_b, n_w	=	Manning's roughness factor for the flume (overall), bed, and wall respectively
V	=	average velocity of flow in fps
S	=	channel slope in ft/ft
p	=	wetted perimeter of channel = w + 2D, in ft
p_b	=	wetted perimeter for bed = w, in ft
p_w	=	wetted perimeter for walls = 2D, in ft
R	=	hydraulic radius of channel = A/p = wD/(w+20), ih ft
R_b	=	hydraulic radius for bed = A_b/p_b, in ft
R_w	=	hydraulic radius for walls = A_w/p_w, in ft
w	=	channel width = 8 ft
D	=	water depth in ft

Substituting the values of $p_b = w = 8$ ft, $P_w = 2D$, and $n_w = 0.012$ (for smooth painted wall and plexiglas, Chow, 1959, p. 110-111) in equation (3.3) results in

$$n_b = \left[\frac{n^{3/2}\,p - (0.012)^{3/2}\,(2D)}{8}\right]^{2/3} \tag{3.4}$$

The value of n_b calculated from equation (3.4) can be used to calculate the vlaues of the average shear stress on bed and the bed Shields' coefficient. The calculation procedure is as follows:

1. Calculate n from equation (3.1) for known values of V, R, and S.
2. Calculate n_b from equation (3.4).
3. Calculate R_b from equations (3.2) for known values of R and n.
4. Calculate average shear stress on bed using the relationship

$$\tau_b = \gamma_w R_b S \tag{3.5}$$

   where γ_w is the unit weight of water.

5. Calculate C_b using the relaionship

$$C_b = \frac{\tau_b}{(\gamma_S - \gamma_w)\,d_{50}} = \frac{\gamma_w R_b S}{(\gamma_S - \gamma_w)\,d_{50}} = \frac{R_b S}{(s-1)\,d_{50}} \tag{3.6}$$

where γ_S is the specific weight of rock, s is the specific gravity of rocks (γ_s/γ_w), and d_{50} is median size of the riprap in ft.

The values of n, n_b, and C_b are calculated by the above procedure and results are presented in Tables 3.1 to 3.5. The values of bed Shield's coefficient for incipient failure runs will be termed the bed critical Shields' coefficient; the bed critical Shields' coefficient calculated by this method (using Manning's roughness factor) will be denoted by C_{cn}.

In addition of the bed Shield's coefficient, the values of the overall Shields' coefficient C, are also calculated and presented in Table 3.1 to 3.5. The overall Shields' coefficient is defined as:

$$C = \frac{DS}{(s - 1)\, d_{50}} \tag{3.7}$$

The values of C for incipient failure runs will be termed the overall critical Shields' coefficient and will be denoted by C_c.

The range and average values of the bed Manning's roughness factor, for the five series of tests, are summarized in Table 3.6. This Table also contains the values of Manning's roughness factor calculated by the two following equations:

1. Anderson et al. (1970) equation

$$n = 0.0395\, d_{50}^{\;1/6} \tag{3.8}$$

where d_{50} is in feet, and

2. Strickler's equation (Simons and Senturk, 1977, p. 309)

$$n = d_{90}^{\;1/6} / 26$$

where d_{90} is in meters.

The results in Table 3.6 show that 1) the values of n obtained by Anderson et al. equation are in agreement with the values of n_b obtained experimentally; and 2) Strickler's equation underestimates the bed Manning's roughness factor.

The coefficient of Strickler's equation was modified in order to fit the data. The modified equation is:

$$n = d_{90}^{1/6}/22.4 \quad (d_{90} \text{ in meters}) \tag{3.10}$$

The coefficient 1/22.4 was obtained by calculating the corresponding coefficient of Strickler's equation for each n_b value given in Tables 3.1 to 3.5 and then averaging all coefficients. The calculated values of n from equation (3.10) are also presented in Table 3.6.

Run #	Nominal discharge Q cfs	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number F	Wetted premeter p=w+2D ft	Hydraulic radius R, ft	Overall Manning coef. n	Bed Manning coef. n_b	Bed Hydraulic radius R_b, ft	Bed Shields coef. C_b	Area washed sq. ft	Overall Shields coef. C
1	25	0.00367	2.57	1.273	0.40	10.58	0.966	0.034	0.040	1.209	0.032		0.033
2	25	0.00490	3.56	0.906	0.66	9.81	0.739	0.024	0.026	0.847	0.030		0.032
3	25	0.00617	3.87	0.846	0.74	9.69	0.698	0.024	0.026	0.793	0.035		0.037
4	25	0.00749	4.22	0.746	0.86	9.49	0.628	0.022	0.024	0.699	0.037		0.040
5	25	0.00872	4.48	0.714	0.93	9.43	0.606	0.022	0.024	0.672	0.042	2	0.044
f 6	25	0.01012	4.59	0.689	0.97	9.38	0.588	0.023	0.025	0.661	0.047	23	0.050
• 7	25	0.00869	4.77	0.714	0.99	9.43	0.606	0.021	0.022	0.667	0.041		0.044
28	50	0.00409	3.85	1.386	0.58	10.77	1.029	0.025	0.029	1.269	0.037		0.040
29	50	0.00490	4.30	1.262	0.67	10.52	0.959	0.024	0.027	1.152	0.040		0.044
30	50	0.00561	4.76	1.252	0.75	10.50	0.954	0.023	0.026	1.137	0.046	0.03	0.050
• 31	50	0.00561	5.06	1.262	0.79	10.52	0.959	0.021	0.024	1.135	0.045		0.051
20	75	0.00284	5.03	2.018	0.62	12.04	1.341	0.019	0.022	1.684	0.034		0.041
21	75	0.00333	5.14	1.886	0.66	11.77	1.202	0.020	0.023	1.600	0.038		0.045
f 22	75	0.00407	4.84	1.802	0.61	11.60	1.242	0.024	0.028	1.600	0.047	12	0.052
• 23	75	0.00343	5.02	1.885	0.64	11.77	1.201	0.021	0.024	1.615	0.040		0.046
24	100	0.00225	4.86	2.479	0.54	12.96	1.530	0.019	0.023	2.014	0.032		0.040
25	100	0.00266	4.62	2.397	0.53	12.79	1.499	0.022	0.027	2.030	0.039		0.046
26	100	0.00308	5.15	2.286	0.60	12.57	1.488	0.021	0.025	1.917	0.042	2	0.050
• 27	100	0.00318	5.06	2.337	0.58	12.67	1.478	0.022	0.026	1.970	0.045	0.7	0.053

f Failure conditions
• Incipient failure conditions

Table 3.1. Calculation of Manning's and Shields' Coefficients For Riprap of d_{50} = 1 in. and Thickness = 2 in.

Run #	Nominal discharge Q cfs	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number F	Wetted premeter p=w+2D ft	Hydraulic radius R, ft	Overall Manning coef. n	Bed Manning coef. n_b	Bed hydraulic radius R_b, ft	Bed Shields coef. C_b	Area washed sq. ft	Overall Shields coef. C
33	25	0.00998	4.40	0.684	0.94	9.37	0.584	0.024	0.025	0.648	0.046		0.049
34	25	0.01088	4.51	0.703	0.95	9.41	0.598	0.024	0.026	0.667	0.052		0.055
35	25	0.01186	4.72	0.672	1.01	9.34	0.575	0.024	0.025	0.637	0.054		0.057
f 36	25	0.01337	4.95	0.618	1.11	9.24	0.535	0.023	0.024	0.587	0.066	7.2	0.059
* 37	25	0.01204	4.77	0.681	1.04	9.30	0.560	0.023	0.025	0.617	0.063	2.7	0.056
f 32	50	0.00558	4.90	1.300	0.76	10.60	0.981	0.022	0.025	1.175	0.047	10.8	0.052
* 41	50	0.00475	4.71	1.383	0.71	10.71	1.011	0.022	0.025	1.215	0.041	2.5	0.046
f 38	75	0.00402	5.02	1.832	0.65	11.66	1.257	0.022	0.026	1.599	0.046	0.4	0.053
f 39	75	0.00377	5.00	1.842	0.65	11.68	1.261	0.021	0.025	1.597	0.043	0.1	0.050
* 40	75	0.00348	4.84	1.918	0.62	11.84	1.296	0.021	0.025	1.659	0.041		0.047
42	100	0.00314	4.97	2.371	0.57	12.74	1.489	0.022	0.027	2.013	0.045		0.053
43	100	0.00403	4.90	2.415	0.56	12.83	1.506	0.025	0.032	2.119	0.061		0.070
f 44	100	0.00436	5.20	2.210	0.62	12.42	1.424	0.024	0.029	1.931	0.060	17.7	0.069
* 45	100	0.00384	5.09	2.332	0.59	12.66	1.473	0.023	0.028	1.999	0.061	2.5	0.069

f Failure conditions
* Incipient failure conditions

Table 3.2. Calculation of Manning's and Shields' Coefficients for Riprap of d_{50} = 1 in. and Thickness = 2 in. (after removing flat rocks).

Run #	Nominal discharge Q cfs	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number F	Wetted premeter p=w+2D ft	Hydraulic radius R, ft	Overall Manning coef. n	Bed Manning coef. n_b	Bed Hydraulic radius R_b, ft	Bed Shields coef. C_b	Area washed sq. ft	Overall Shields coef. C
46	25	0.00880	4.37	0.720	0.91	9.44	0.610	0.023	0.025	0.679	0.043		0.048
47	25	0.01011	4.61	0.688	0.98	9.38	0.587	0.023	0.024	0.649	0.047		0.050
48	25	0.01313	5.02	0.640	1.11	9.28	0.552	0.023	0.024	0.606	0.057		0.060
• 57	25	0.01475	5.02	0.625	1.12	9.25	0.541	0.024	0.026	0.595	0.063		0.066
f 58	25	0.01626	5.82	0.568	1.29	9.14	0.497	0.022	0.023	0.539	0.063	23	0.066
49	50	0.00526	4.94	1.268	0.77	10.54	0.963	0.021	0.024	1.139	0.043		0.048
50	50	0.00636	5.36	1.169	0.87	10.34	0.905	0.021	0.023	1.053	0.048		0.053
52	50	0.00726	5.74	1.096	0.97	10.19	0.860	0.020	0.022	0.987	0.051		0.057
f 53	50	0.00802	5.66	1.098	0.96	10.19	0.860	0.021	0.024	0.996	0.057	37.4	0.063
f 54	50	0.00732	5.64	1.111	0.94	10.22	0.869	0.021	0.023	1.004	0.052	2.3	0.058
f 55	50	0.00732	5.03	1.245	0.79	10.49	0.949	0.024	0.028	1.144	0.060	3.7	0.065
• 56	50	0.00647	5.11	1.231	0.81	10.46	0.941	0.023	0.025	1.118	0.052		0.057
59	75	0.00423	4.90	1.907	0.63	11.81	1.201	0.023	0.028	1.682	0.051		0.058
• 60	75	0.00517	5.11	1.814	0.67	11.63	1.248	0.024	0.029	1.618	0.060		0.067
f 61	75	0.00521	5.50	1.714	0.74	11.43	1.200	0.024	0.028	1.533	0.068	49.5	0.076
62	100	0.00406	4.63	2.513	0.51	13.03	1.543	0.027	0.035	2.232	0.065		0.073
f 63	100	0.00457	5.25	2.210	0.62	12.42	1.424	0.024	0.030	1.937	0.063	2	0.072
• 64	100	0.00409	5.10	2.298	0.59	12.60	1.460	0.024	0.030	2.002	0.058		0.067

f Failure conditions

• Incipient failure conditions

Table 3.3. Calculation of Manning's and Shields' Coefficients for Riprap of d_{50} = 1 in. and Thickness = 3 in.

Run #	Nominal discharge Q cfs	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number F	Wetted premeter p=w+2D ft	Hydraulic radius R, ft	Overall Manning coef. n	Bed Manning coef. n_b	Bed Hydraulic radius R_b, ft	Bed Shields coef. C_b	Area washed sq. ft	Overall Shields coef. C
76	24.8	0.01193	4.85	0.681	0.87	9.36	0.682	0.026	0.027	0.626	0.027		0.030
77	26.2	0.01888	5.27	0.898	1.20	9.20	0.520	0.026	0.027	0.554	0.038		0.041
65	50.1	0.00998	5.03	1.246	0.79	10.49	0.950	0.029	0.033	1.089	0.040		0.046
66	50.0	0.01378	6.13	1.019	1.07	10.04	0.812	0.025	0.028	0.901	0.045		0.051
• 67	50.2	0.01519	6.36	0.987	1.13	9.97	0.792	0.026	0.027	0.876	0.049		0.055
68	50.2	0.01796	6.71	0.938	1.22	9.87	0.758	0.025	0.027	0.834	0.055		0.061
f 69	50.3	0.01888	6.63	0.948	1.20	9.90	0.766	0.026	0.029	0.847	0.059	59.8	0.065
f 78	50.2	0.01579	6.14	1.022	1.07	10.04	0.814	0.027	0.030	0.908	0.052	5.5	0.059
f 70	75.0	0.01110	6.65	1.410	0.99	10.82	1.043	0.024	0.028	1.197	0.049	64.1	0.057
71	75.1	0.00781	5.33	1.483	0.92	10.97	1.082	0.022	0.026	1.236	0.035		0.042
• 72	77.5	0.00937	6.81	1.423	1.01	10.86	1.080	0.022	0.025	1.193	0.041		0.049
73	100.5	0.00731	6.43	1.954	0.81	11.91	1.313	0.024	0.028	1.574	0.042		0.052
• 74	100.2	0.00840	6.82	1.891	0.85	11.78	1.284	0.024	0.029	1.537	0.047		0.058
f 75	101.0	0.01066	7.00	1.804	0.92	11.61	1.243	0.025	0.030	1.484	0.058	27	0.070

f Failure condition
• Incipient failure conditions

Table 3.4. Calculation of Manning's and Shields' Coefficients for Riprap of d_{50} = 2 in. and Thickness = 4 in.

Run #	Nominal discharge Q cfs	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number F	Wetted premeter p=w+2D ft	Hydraulic radius R, ft	Overall Manning coef. n	Bed Manning coef. n_b	Bed Hydraulic radius R_b, ft	Bed Shields coef. C_b	Area washed sq. ft	Overall Shields coef. C
79	25	0.01180	4.42	0.710	0.92	9.42	0.603	0.026	0.028	0.651	0.028		0.031
80	25	0.01870	5.17	0.607	1.17	9.21	0.527	0.026	0.027	0.563	0.039		0.042
81	50	0.01205	5.90	1.068	1.01	10.14	0.843	0.026	0.026	0.940	0.041		0.047
82	50	0.01544	6.47	0.966	1.16	9.93	0.778	0.024	0.027	0.858	0.048		0.056
83	50	0.01724	6.76	0.928	1.24	9.86	0.753	0.024	0.026	0.827	0.052		0.059
• 84	50	0.01879	6.61	0.970	1.18	9.94	0.781	0.026	0.029	0.866	0.059		0.067
85	75	0.00898	6.19	1.519	0.89	11.04	1.101	0.024	0.028	1.276	0.042		0.050
86	75	0.01098	6.88	1.414	0.98	10.83	1.045	0.024	0.028	1.200	0.048		0.057
87	75	0.01206	6.63	1.423	0.98	10.85	1.050	0.026	0.029	1.212	0.053		0.063
• 88	75	0.01359	6.80	1.372	1.04	10.74	1.022	0.026	0.029	1.175	0.058		0.068
f 89	75	0.01565	6.84	1.399	1.02	10.80	1.036	0.028	0.032	1.203	0.069	9.6	0.080
90	100	0.00866	6.97	1.808	0.91	11.62	1.245	0.023	0.027	1.469	0.047		0.057
91	100	0.00938	6.96	1.796	0.92	11.59	1.239	0.024	0.028	1.468	0.050		0.062
92	100	0.01084	7.39	1.711	1.00	11.42	1.198	0.024	0.028	1.408	0.056		0.068
• 93	100	0.01189	7.44	1.698	1.01	11.40	1.192	0.025	0.029	1.405	0.061		0.074
f 94	100	0.01300	8.02	1.572	1.13	11.14	1.128	0.023	0.027	1.306	0.062	15	0.078

f Failure conditions
• Incipient failure conditions

Table 3.5. Calculation of Manning's and Shields' Coefficients for Riprap of d_{50} = 2 in. and Thickness = 6 in.

Table 3.6 Values of Bed Manning's Roughness Factor Calculated From Experimental Data And Equations Listed

Test Series #	Riprap Size d_{50} in.	d_{90} in.	Experimental data n_b range	n_b average	Anderson et al. equation	Strickler equation	Modified Strickler equation
1	1	1.3	.022-.029	0.026			
2	1	1.3	.024-.032	0.026			
3	1	1.3	.022-.035	0.026			
1,2,3	1	1.3	.022-.035	0.026	0.026	0.022	0.025
4	2	1.3	.025-.033	0.028			
5	2	2.9	.026-.032	0.028			
4,5	2	2.9	.025-.033	0.028	0.029	0.025	0.029

3.2 Calculation of Bed Critical Shields' Coefficient Using Darcy-Weisbach Friction Factor For Riprap Surface

This method is similar to the method presented in Section 3.1, that is, a side-wall correction technique which results in average values of shear stress on bed and bed Shields' coefficient. The only difference between these two methods is that in section 3.1 the Manning's equation was used to describe the relationship between resistance to flow and hydraulic parameters while in this section the Darcy-Weisbach equation is used to describe such a relationship. The development of the equations for this method are presented in the 1982 Report (p. 22). The resulting equations are:

$$C_b = \frac{R_b S}{(s-1)\, d_{50}} \tag{3.11}$$

$C_{cf} = C_b$ for incipient failure runs

$$\frac{V^2}{8} = \frac{gSR}{f} = \frac{gSR_b}{f_b} \tag{3.12}$$

$$f_b = f + \frac{D}{4}(f - f_w) \tag{3.13}$$

$$\frac{R_w}{f_w} = \frac{R}{f} \tag{3.14}$$

where

C_b	=	bed Shields' coefficient
C_{cf}	=	bed critical Shield's coefficient
R_b	=	hydraulic radius for bed in ft
R	=	channel hydraulic radius in ft
f, f_b, f_w	=	Darcy-Weisbach friction factor for the flume, bed and wall respectively
R, R_w	=	Reynolds number for channel and wall respectively

The calculated values of the bed critical Shields' coefficient for incipient failure conditions (C_{cf}) are presented in Table 3.7.

Riprap median size in.	Riprap thickness in.	Nominal discharge Q cfs	Run #	Flume slope S	Average velocity V, fps	Average depth D, ft	Overall hydraulic radius R, ft	Reynolds number R	Overall friction factor f	R/f	Wall friction factor f_w	Bed friction factor f_b	Bed hydraulic radius R_b	Bed Shields coef. C_{cf}
1	2	25	7	0.00869	4.77	0.714	0.606	1.16E+06	0.060	1.94E+07	0.015	0.068	0.688	0.043
1	2	50	31	0.00561	5.06	1.262	0.959	1.94E+06	0.054	3.59E+07	0.013	0.067	1.188	0.048
1	2	75	23	0.00343	5.02	1.885	1.281	2.57E+06	0.045	5.73E+07	0.012	0.060	1.720	0.042
1	2	100	27	0.00318	5.06	2.337	1.475	2.99E+06	0.047	6.33E+07	0.012	0.068	2.116	0.048
1	2	25	37	0.01204	4.77	0.651	0.560	1.07E+06	0.076	1.40E+07	0.015	0.086	0.633	0.054
1	2	50	41	0.00475	4.71	1.353	1.011	1.90E+06	0.056	3.42E+07	0.013	0.070	1.271	0.043
1	2	75	40	0.00345	4.84	1.918	1.296	2.51E+06	0.049	5.10E+07	0.012	0.067	1.761	0.043
1	2	100	45	0.00354	5.09	2.332	1.473	3.00E+06	0.052	5.78E+07	0.012	0.075	2.128	0.054
1	3	25	57	0.01475	5.02	0.625	0.541	1.09E+06	0.082	1.33E+07	0.016	0.092	0.609	0.064
1	3	50	56	0.00647	5.11	1.231	0.941	1.92E+06	0.060	3.20E+07	0.014	0.074	1.166	0.054
1	3	75	60	0.00517	5.11	1.814	1.248	2.55E+06	0.064	4.01E+07	0.013	0.087	1.698	0.063
1	3	100	64	0.00409	5.10	2.298	1.460	2.98E+06	0.059	5.04E+07	0.013	0.086	2.121	0.062
2	4	50	67	0.01519	6.36	0.987	0.792	2.01E+06	0.077	2.63E+07	0.014	0.092	0.952	0.052
2	4	75	72	0.00937	6.81	1.423	1.050	2.86E+06	0.055	5.23E+07	0.012	0.070	1.338	0.045
2	4	100	74	0.00840	6.62	1.891	1.284	3.40E+06	0.063	5.36E+07	0.012	0.088	1.772	0.053
2	6	50	84	0.01879	6.61	0.970	0.781	2.06E+06	0.086	2.39E+07	0.014	0.104	0.939	0.063
2	6	75	88	0.01359	6.88	1.372	1.022	2.81E+06	0.076	3.72E+07	0.013	0.097	1.311	0.064
2	6	100	93	0.01189	7.44	1.698	1.192	3.55E+06	0.066	5.38E+07	0.012	0.089	1.603	0.068

Table 3.7 Calculation of Bed Critical Shields' Coefficient Using Darcy Weisbach Friction Factor

3.3 Calculation Of Bed Critical Shields Coefficient Using Velocity Distribution Equation

The Prandtl-Von Karman velocity distribution equation is used in this section to calculate the bed critical Shields' coefficient C_{cv}. The Prandtl-Von Karman equation is presented as (Chow, 1959, p. 202)

$$U = 5.75\, U_* \log \frac{30z}{k_s} \qquad (3.15)$$

where

U	=	velocity at height z [L/T] in ft/sec
U_*	=	shear velocity [L/T] in ft/sec
z	=	vertical height above the "bed" [L] in ft
k_s	=	equivalent roughness height [L] in ft

Equation (3.15) can be written as

$$U = 5.75\, U_* \log z + 5.75\, U_* \log \frac{30}{k_s} \qquad (3.16)$$

or

$$U = a \log z + b \qquad (3.17)$$

where

$$a = 5.75\, U_* \qquad (3.18)$$

$$b = 5.75\, U_* \log \frac{30}{k_s} \qquad (3.19)$$

Equation (3.17) indicates that if velocities are plotted versus depth on semi-logarithmic paper the value of shear velocity, U_*, can be determined from the slope of the line passing through the data points. The value of "b" can be evaluated by using known points on the line. The magnitude of k_s then can be calculated from equation (3.19). For a known value of U_*, the critical bed shear stress, τ_c, and corresponding Shields' coefficient, C_{cv} can be determined as follows:

$\tau_c = \tau_b$ for incipient failure runs

$$\tau_c = \rho U_*^2 \tag{3.20}$$

$$C_{cv} = \frac{\tau_c}{(\gamma_s - \gamma_w)\, d_{so}} \tag{3.21}$$

where

γ_s = specific weight of rocks
γ_w = unit weight of water

The graphs of velocity distribution versus depth for incipient motion runs are presented in Appendix C (indicated by the run number). The calculated values of C_{cv} and k_s are presented Tables 3.8 and 3.9. The values of C_{cv} and k_s are obtained from the velocity profiles along the centerline of the flume (Y=4.0 ft) and across the middle section of the test reach (X=125 ft for run No. 7 and X=130 ft for the rest of the runs). When the velocity profile lines were drawn through the data points adjacent to the riprap surface low values for C_{cv} and k_s resulted. Examples are run No. 57 (Y=4.0 ft, line #2) and run No. 84 (Y=4.0 ft, line #3) where C_{cv} = 0.020.

To evaluate the effect of the bottom elevation on the logarithmic distribution of the velocity profile, a comparison was made between velocity profiles plotted using four different elevation datums. Two of these datums are the "general datum" (GD) and the "local datum" (LD) as defined in Chapter 2. The other two datums are selected to be a distance $d_{so}/2$ below the GD and LD (that is, GD - $d_{so}/2$ and LD - $d_{so}/2$). The velocity distribution for some selected runs (runs No. 67, 74, 76, 84, 88, and 93) are plotted using these four datums. The graphs of velocity distributions for these runs are presented in Appendix C. As shown in these graphs, the data points adjacent to the riprap surface did not coincide with the velocity distribution line drawn through the remainder of the data points when the "local datum" was used. The effect of using these four different datums to evaluate the

bed Shields' coefficient C_{cv} can be observed by referring to the values presented in Table 3.10. These values indicate that the magnitudes of C_{cv} are generally highest when the LD - $d_{50}/2$ datum is used, and lowest when "general datum" is used. In the next section, the values of C_{cv} that are obtained using the "general datum" will be compared with the values of Shields' coefficient obtained in sections 3.1 and 3.2.

RUN #	Riprap Thickness in.	Discharge Q cfs	Location of vel. profile	Line #	b	a	b/a	U* fps	Bed shear stress psf	Critical Shields coef.	Roughnes factor k_s,ft
7	2	25	Y=4.0'		6.03	3.00	2.010	0.522	0.528	0.060	0.293
			X=125'		6.17	3.27	1.887	0.569	0.627	0.072	0.389
31		50	Y=4.0'		5.77	3.07	1.879	0.534	0.552	0.063	0.396
			X=130'	1	5.67	2.97	1.909	0.517	0.517	0.059	0.370
				2	6.03	2.96	2.037	0.515	0.514	0.059	0.275
23		75	Y=4.0'		5.60	2.90	1.931	0.504	0.493	0.056	0.352
			X=130'		5.43	2.73	1.989	0.475	0.437	0.050	0.308
27		100	Y=4.0'		4.83	2.60	1.858	0.452	0.396	0.045	0.416
			X=130'	1	4.83	2.50	1.932	0.435	0.366	0.042	0.351
				2	5.57	3.07	1.814	0.534	0.552	0.063	0.460
									Average	0.057	0.361
37	2	25	Y=4.0'		6.53	3.16	2.066	0.550	0.585	0.067	0.257
			X=130'		6.70	3.37	1.988	0.586	0.666	0.076	0.308
41		50	Y=4.0'		5.33	3.10	1.719	0.539	0.563	0.064	0.572
			X=130'		5.40	2.67	2.022	0.464	0.418	0.048	0.285
40		75	Y=4.0'		5.27	2.40	2.196	0.417	0.338	0.039	0.191
			X=130'		5.33	2.36	2.258	0.410	0.326	0.037	0.165
45		100	Y=4.0'		4.83	2.13	2.268	0.370	0.266	0.030	0.162
			X=130'		5.23	2.43	2.152	0.423	0.346	0.040	0.211
									Average	0.050	0.269
57	3	25	Y=4.0'	1	6.40	3.33	1.922	0.579	0.650	0.074	0.359
				2	5.63	1.73	3.254	0.301	0.175	0.020	0.017
			X=130'	1	7.23	3.90	1.854	0.678	0.892	0.102	0.420
				2	6.83	2.90	2.353	0.504	0.493	0.029	0.132
56		50	Y=4.0'		5.90	3.10	1.903	0.539	0.563	0.064	0.375
			X=130'	1	5.73	2.60	2.204	0.452	0.396	0.045	0.188
				2	6.07	3.17	1.915	0.551	0.589	0.067	0.365
60		75	Y=4.0'		5.70	3.43	1.662	0.597	0.690	0.079	0.654
			X=130'		6.03	2.46	2.451	0.428	0.355	0.041	0.106
64		100	Y=4.0'		5.17	2.44	2.119	0.424	0.349	0.041	0.228
			X=130'		5.53	2.50	2.212	0.435	0.366	0.042	0.184
									Average	0.055	0.275

Table 3.8 Calculation of Bed Critical Shields' Coefficient Using Velocity Distribution Equation for d_{50} = 1 in. Riprap.

RUN #	Riprap thickness in.	Discharge Q cfs	Location of vel. profile	Location of origin (Z=0)	Line #	b	a	b/a	U_* fps	Bed shear stress psf	Critical Shields coef.	Roughness factor k_s, ft
67	4	50	Y=4.0'	GD	1	8.00	4.13	1.937	0.718	1.000	0.059	0.347
					2	7.90	3.67	2.153	0.638	0.789	0.046	0.211
				GD-d50/2		6.70	3.70	1.811	0.643	0.802	0.047	0.464
				LD		7.87	4.67	1.685	0.812	1.278	0.075	0.619
				LD-d50/2		6.80	4.73	1.438	0.823	1.311	0.077	1.095
72		75	Y=4.0'	GD		7.56	3.83	1.974	0.666	0.860	0.050	0.319
			X=130'	GD	1	7.80	3.77	2.069	0.656	0.833	0.049	0.256
					2	7.87	2.97	2.650	0.517	0.517	0.030	0.067
74		100	Y=4.0'	GD	1	6.80	3.13	2.173	0.544	0.574	0.034	0.202
					2	7.40	3.13	2.364	0.544	0.574	0.034	0.130
			X=130'	GD		7.40	3.17	2.334	0.551	0.589	0.035	0.139
				GD-d50/2		7.20	3.69	1.951	0.642	0.798	0.047	0.336
				LD		7.33	3.83	1.914	0.666	0.860	0.050	0.366
				LD-d50/2		7.12	4.33	1.644	0.783	1.099	0.064	0.680
										Average	0.050	0.374
84	6	50	Y=4.0'	GD	1	8.27	3.77	2.194	0.656	0.833	0.049	0.192
					2	7.73	3.30	2.342	0.574	0.638	0.037	0.136
					3	7.93	2.43	3.263	0.423	0.346	0.020	0.016
				GD-d50/2	1	8.20	4.86	1.687	0.845	1.384	0.081	0.616
					2	7.93	4.85	1.635	0.843	1.379	0.081	0.695
					3	8.39	4.16	2.017	0.723	1.014	0.059	0.289
				LD	1	7.87	4.70	1.674	0.817	1.295	0.076	0.635
					2	8.03	3.03	2.650	0.527	0.538	0.032	0.067
				LD-d50/2	1	7.70	5.96	1.292	1.037	2.082	0.122	1.532
					2	8.50	4.89	1.738	0.850	1.402	0.082	0.548
88		75	Y=4.0'	GD		8.30	4.07	2.039	0.708	0.971	0.057	0.274
				GD-d50/2		8.16	5.04	1.619	0.877	1.489	0.087	0.721
				LD	1	8.10	4.87	1.663	0.847	1.390	0.082	0.651
					2	8.40	4.17	2.014	0.725	1.019	0.060	0.290
				LD-d50/2	1	7.80	5.47	1.426	0.951	1.754	0.103	1.125
					2	8.40	5.38	1.561	0.936	1.697	0.099	0.824
93		100	Y=4.0'	GD		8.36	4.86	1.720	0.845	1.384	0.081	0.571
				GD-d50/2		8.10	5.44	1.489	0.946	1.735	0.102	0.973
				LD		8.23	5.00	1.646	0.870	1.465	0.086	0.678
				LD-d50/2		7.93	5.80	1.367	1.009	1.972	0.116	1.288
										Average	0.076	0.606

GD = General Datum
LD = Local Datum

Table 3.9 Calculation of Bed Critical Shields' Coefficient Using Velocity Distribution Equation for d_{50} = 2 in. Riprap.

Table 3.10. Values of C_{cv} for Some Selected Runs Calculated Based on Four Different Datums

Run #	Discharge Q cfs	Location of vel. profile	Line #	Datums GD	GD-d_{50}/2	LD	LD-d_{50}/2
76	25	X=130'		0.020	0.039	0.028	0.056
67	50	Y=4.0'	1	0.059	0.047	0.075	0.077
	50		2	0.046			
74	100	X=130'		0.035	0.047	0.050	0.064
84	50	Y=4.0'	1	0.049	0.081	0.076	0.122
	50		2	0.037	0.081	0.032	0.082
	50		3	0.020	0.059		
88	75	Y=4.0'	1	0.057	0.087	0.082	0.103
	75		2			0.060	0.099
93	100	Y=4.0'		0.081	0.102	0.086	0.116

GD = General Datum
LD = Local Datum
Note: More than one value of C_{cv} for a given run resulted from different velocity distribution profiles along a section.

3.4 Comparison Of The Values Of Critical Shields' Coefficients Calculated By The Previous Three Methods

In Table 3.11 The calculated values of critical Shields' coefficient are presented for comparison. The results show that values of bed critical Shields' coefficient obtained using the Manning's friction factor (C_{cn}) have the lowest magnitudes and those obtained by Prandtl-Von Karman equation (C_{cv}) have generally (for 60% of the time) the highest magnitudes. However, some very low values of the Shields' coefficient were obtained using the Prandtl-Von Karman equation.

The values of C_{cv} that are presented in Table 3.11 were calculated based on the "general datum". As mentioned in the previous section, the values of C_{cv} that were calculated based on the other three datums are higher than the ones obtained using the "general datum" and, therefore, much higher than the values of C_{cn} and C_{cf}. Because of the wide range of values of C_{cv} (as shown in Tables 3.10 and 3.11), a general conclusion cannot be made as if the values of C_{cv} represent the actual values of bed critical Shields' coefficient or not. This raises the question of the validity of the Prandtl-von Karman equation in predicting the shear stress on the riprap surface, τ_b, and, therefore, bed Shields' coefficient.

3.5 Effect Of Flat Rocks

The 1 in. riprap contained about 10 percent flat rocks. To determine the influence of these flat rocks on the failure of the riprap, the flat rocks were removed after the first series of tests and the tests were repeated.

No significant changes in critical Shields' coefficient were observed after removal of flat rocks. The values of critical Shields' coefficient differ appreciably only for a flow rate of 25 cfs (see Table 3.11 - runs No. 7 and 37). This difference is probably due to the influence of the transition section of run No. 7 as mentioned earlier and not attributed to removal of the flat rocks.

Table 3.11. Values of Critical Shields Coefficients Calculated by Different Methods Listed

Run #	Riprap median size in.	Riprap thicknes in	Discharge Q cfs	Overall C_c	Manning C_{cn}	Darcy Weisbach C_{cf}	Velocitydistrib. C_{cv} @Y=4.0'	Velocitydistrib. C_{cv} @X=130'
7	1	2	25	0.044	0.041	0.043	0.060	0.072
31			50	0.051	0.045	0.048	0.063	0.059
23			75	0.046	0.040	0.042	0.056	0.050
27			100	0.053	0.045	0.048	0.045	0.042
			100					0.063
37	1	2	25	0.056	0.053	0.054	0.067	0.076
41			50	0.046	0.041	0.043	0.064	0.048
40			75	0.047	0.041	0.043	0.039	0.037
45			100	0.059	0.051	0.054	0.030	0.040
57	1	3	25	0.066	0.063	0.064	0.074	0.102
			25				0.020	0.033
56			50	0.057	0.052	0.054	0.064	0.045
			50					0.067
60			75	0.067	0.060	0.063	0.079	0.041
64			100	0.067	0.058	0.062	0.041	0.042
67	2	4	50	0.055	0.049	0.052	0.059	
			50				0.046	
72			75	0.049	0.041	0.045	0.050	0.049
			75					0.030
74			100	0.058	0.047	0.053	0.034	0.035
84	2	6	50	0.067	0.059	0.063	0.049	
			50				0.037	
			50				0.020	
88			75	0.068	0.058	0.064	0.057	
93			100	0.074	0.061	0.068	0.081	

Note: More than one value of C_{cv} for a given run resulted from different velocity distribution profiles along a section.

3.6 Effect Of The Riprap Thickness On Critical Shields' Coefficient(C_c)

The failure criterion for riprap was the exposure of the filter blanket after a run. For a given discharge, the run at which the flume slope was one increment lower than the failure run was regarded as the incipient failure run from which the critical Shields' coefficient was calculated. Based on the above definition of the incipient failure run, it was expected that the riprap with greater thickness would have higher values of critical Shields' coefficient. This is because the Shields' coefficient is used to define a point that is the result of a significant amount of motion of the riprap even prior to what is defined as a failure.

The values of critical Shields' coefficient, C_c, are presented in Table 3.11. These values show that, on the average, the critical Shields' coefficient increased 22 percent for 1 in. rocks and 30 percent for 2 in. rocks when rock thickness increased from $2d_{50}$ to $3d_{50}$. The values of overall critical Shields' coefficient calculated from equation (3.7) (C_c) are plotted in Figure 3.1. The increase in the critical Shields' coefficient as shown in Figure 3.1 was relatively small when the rock size increased from 1 in. to 2 in. (4 percent on the average) and the thickness remained at $2d_{50}$. However, the critical Shields' coefficient increased about 30 percent when rock riprap thickness increased from $2d_{50}$ to $3d_{50}$.

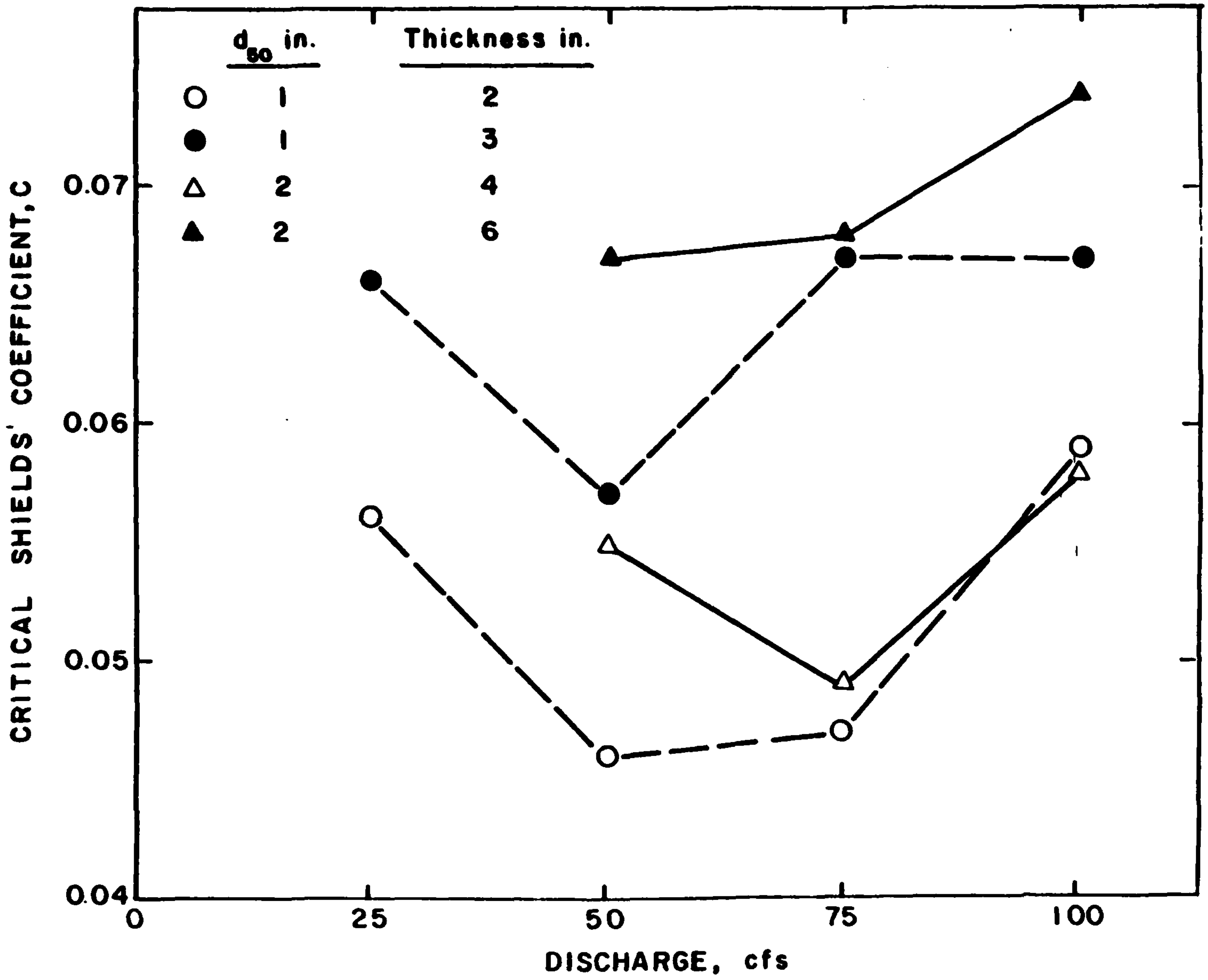

Figure 3.1 Values of overall critical Shields' coefficient for different rock sizes and thicknesses.

3.7 Effect of Riprap Gradation on Critical Shields' Coefficient (C_c)

To examine the effect of gradation, values of overall critical Shields' coefficients are plotted in Figure 3.2 for the riprap materials presented in Table 3.12. The values of d_{85}/d_{15} are used as the parameters to represent the gradation of riprap material. The values of d_{85}/d_{15} in Table 3.12 indicates that the riprap material of this 1985 Study and the 2 in. riprap of the 1982 Report had a more uniform gradation than the 1 in. riprap of the 1983 Report.

As shown in Figure 3.2, the range of values of the critical Shields' coefficients for 1 in. riprap of the 1983 Report was lower than the rest of data points. These results show that a riprap with more uniform gradation is more stable. Additional data are required to generalize the effect of gradation on riprap stability.

TABLE 3.12 Gradation of the Riprap Material

d_{50} in	Riprap Thickness	d_{85}/d_{15}	Year of Study
1	2	2.0	1985
1	2	4.4	1983
2	4	2.4	1985
1.87	4	2.8	1982

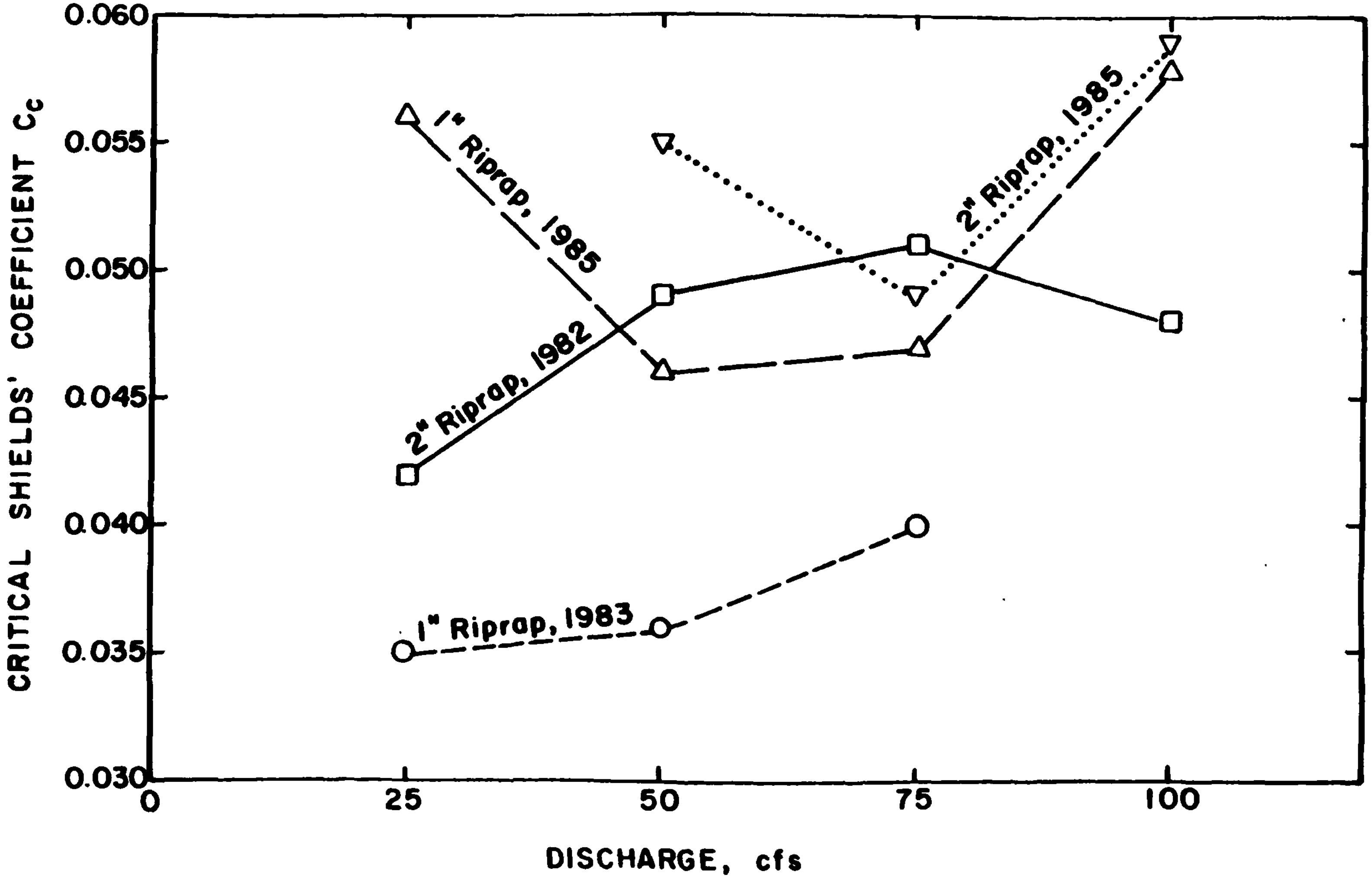

Figure 3.2 Variation of overall critical Shields' coefficient with riprap gradation.

3.8 Comparison With Shields' Diagram

Shields' diamgram is an experimental relationship between the values Shields' coefficient for incipient motion runs ($C_{ci} = \tau_c /(\gamma_w (s-1)d)$) and grain Reynolds number ($R_* = U_* d/\nu$) where U_* is shear velocity in fps, d is particle size in ft, and ν is kinematic viscosity in ft^2/sec. Shields assumed that for a flat bed of uniform particle size, C_{ci} is only a function of R_* (Rouse, 1950). Shields' diagram is shown in Figure 3.3. Shields determined this relationship by measuring the washed out mterial (bed load) at various values of $\tau/(\gamma_w (s-1) d)$ at least twice as large as the critical value (C_{ci}) and then extrapolating to the point of zero washed out material (Gessler, 1971). Gessler (1971) argued that some of Shields bed load measurements were under conditions where ripples and small duens prevailed, and therefore the shear stress on bed was resisted by both bed deformation and grain roughness. Gessler concluded that values of C_{ci} determined by Shields were up to 10 percent too high. Gessler modified the Shields' diagram as shown in Figure 3.3.

To compare the results of this riprap stability study with Shields' diagram, the values of overall critical Shields' coefficient (C_c) versus boundary Reynolds' number ($R_* = U_* d_{50}/ \nu$) are presented in Table 3.13 and plotted in Figure 3.3. In this figure, the values of C_c from the 1982 and 1983 Reports are also plotted. Note that the original Shields' diagram was constructed using the values of Shields' coefficient for incipient motion runs but values of C_c are for the incipient failure runs. the scatter of data points in Figure 3.3 are most probably due to two reasons: 1) In incipient failure runs some of the riprap material may move without exposing the underlying filter blanket. this is more pronounced in rirpraps with greater thicknesses. As shown in Figure 3.3, the values of C_c for $3d_{50}$ thickness riprap are greater than the Shields' coefficient of 0.06. 2) The riprap materials were not uniform in size. The data points in Figure 3.3 represent various riprap gradations.

The data points in Figure 3.3 indicate that the values C_c obtained from the recent study are generally higher than those of the previous reports. There is some overlap between the C_c values of the 2 in. riprap of 1982 Report and the recent data. Agreement does not exist for 1 in. rocks of the 1983 Report and the present study. There is a pronounced difference between the critical Shields' coefficient, C_c, based upon the riprap thickness of $2d_{50}$ and $3d_{50}$. The variations in C_c among various ripraps can be attributed to the differences in thicknesses and gradations of the riprap material. As discussed in section 3.6, it is expected that a riprap with greater thickness requires greater bed shear stress (or Shields' coefficient) to begin to fail. the influence of gradation was discussed in section 3.7. The difference in C_c values for 1 in. riprap ($2d_{50}$ thick) of the 1983 Report and the present study may be because of the differences in gradations of the ripraps. Some of these discrepancies are also because of the procedure to change the flume slope to reach the incipient failure run. The actual point of incipient failure could occur at a point where the slope was between that slope called failure and that slope set one increment lower than failure.

3.9 Maximum Stable Slopes At The Incipient Failure Runs

The slopes of the incipient failure runs versus flow rate are plotted in Figure 3.4. This figure also contains the information from the previous report. No general conclusion can be drawn from this plot.

Table 3.13. Values of C_c and R_*

Riprap median size in.	Riprap thickness in.	Discharge Q cfs	Run #	Overall Shields coef. C_c	Boundary Reynolds number R_*
1	2	25	7	0.044	3725
1	2	50	31	0.051	3979
1	2	75	23	0.046	3802
1	2	100	27	0.053	4077
1	2	25	37	0.056	4186
1	2	50	41	0.046	3791
1	2	75	40	0.047	3847
1	2	100	45	0.059	4296
1	3	25	57	0.066	4540
1	3	50	56	0.057	4220
1	3	75	60	0.067	4579
1	3	100	64	0.067	4584
2	4	50	67	0.055	11580
2	4	75	72	0.049	10921
2	4	100	74	0.058	11920
2	6	50	84	0.067	12768
2	6	75	88	0.068	12914
2	6	100	93	0.074	13438

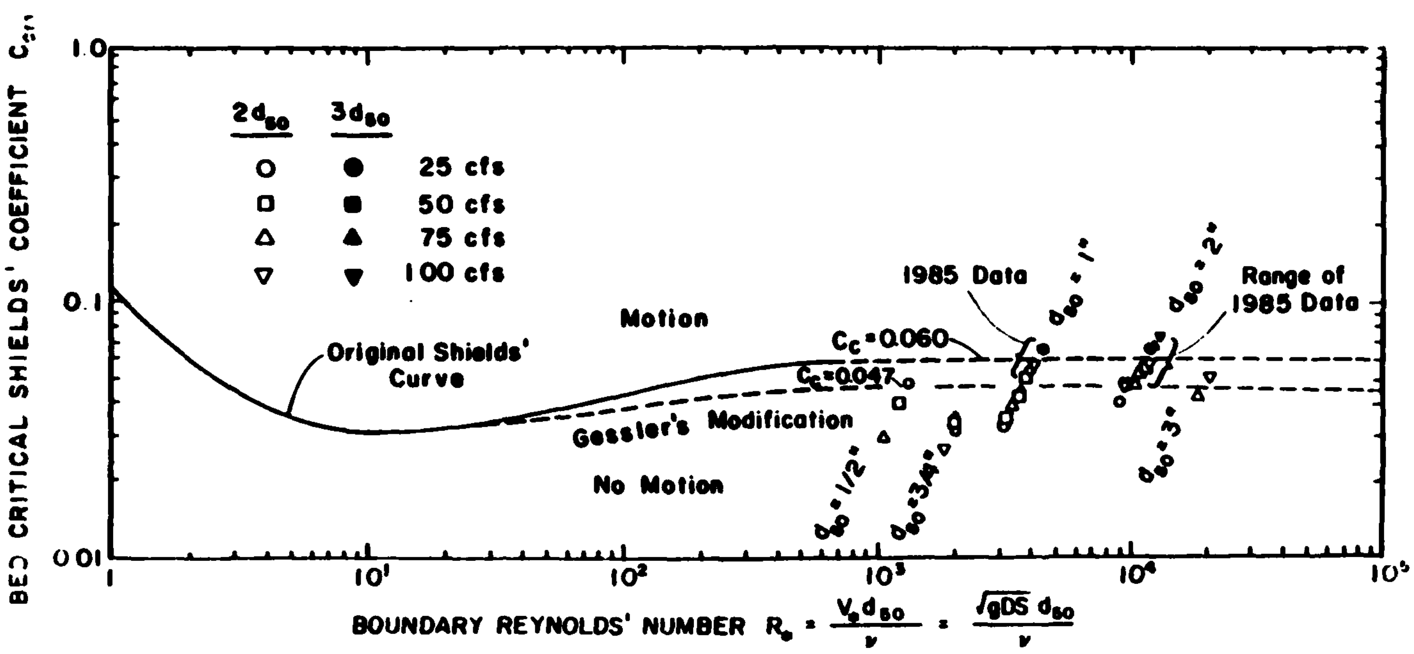

Figure 3.3 The Shields' Diagram

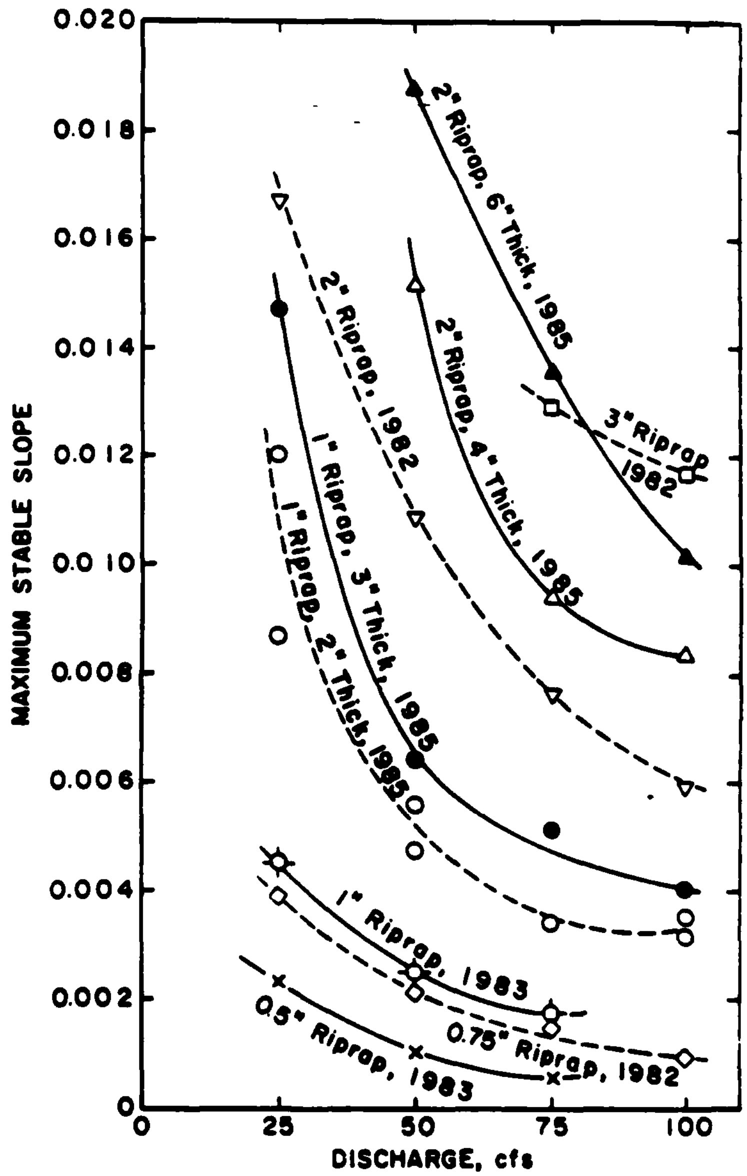

Figure 3.4 Maximum stable slope vs. discharge

CHAPTER 4

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A total of 94 tests were conducted on riprap with d_{50}=1 in. and d_{50}=2 in. and with thickness layers of $2d_{50}$ and $3d_{50}$. The flow rates tested were 25, 50, 75, and 100 cfs. The tests were conducted in the 8 ft tilting flume of the Hydraulics Laboratory, Engineering Research Center of Colorado State University. For each riprap and each flow rate the flume slope was increased by small increments until the failure of the riprap occurred. The exposure of the filter blanket underneath the riprap was the failure criterion. The run with the flume slope reduced one increment lower than the slope at failure was considered to be the incipient failure run. Velocity data were collected either by ott meter or pitot tube. The data are presented in the Appendices.

The following conclusions are made in this study.

1. The average values calculated for bed Manning's roughness, n_b, agree with the ones calculated by Anderson et al. equation. Strickler equation underestimates the bed Manning's roughness factor.
2. The values of bed Shields' coefficient at the incipient failure conditions range from 0.041 to 0.054 for riprap placed $2d_{50}$ thick and range from 0.052 to 0.068 for riprap placed $3d_{50}$ thick. The above values are obtained using the Manning's and Darcy-Weisbach friction factors.

Shields' coefficients calculated using velocity distribution equations, range from 0.020 to 0.102. These differences result from local flow patterns and velocity distributions.

3. No general relationship exists between maximum stable slope and rock size for a given flow rate. There is a trend of the maximum slope increasing with riprap size as shown in Figure 3.4.

4. Generally, The wide range of the results is most likely due to the wide variation in gradations and thicknesses of ripraps.

The recommendations are generally similar to the ones presented in the 1982 and 1983 Reports. It is suggested that a small portion of the riprap be painted and placed in a grid on the surface of the riprap. Displacement of a percentage of painted rocks, then can be used to define the incipient motion or incipient failure runs. Some means should be designed to observe the behavior of the painted rock during a test, for example, using a video camera and recorder.

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APPENDICES

The notations used in the appendices are as follows:

Q	=	nominal discharge, cfs
S	=	bed slope of the flume
D	=	depth of flow, ft
V	=	average velocity, fps
X	=	station along the flume, starting at the upstream end of the flume, ft
Y	=	distance across the flume from the west wall of the flume, ft
Z	=	depth at which velocity was measured (vertical distance above the "general" datum), ft
Rock Size	=	the median size or d_{50} of the riprap, in.
Thickness	=	thickness of the riprap, in.
Fraction of Depth	=	Z/D, measured above the "general" datum
Temp.	=	water temperature, °F

APPENDIX A

SUMMARY

Table A-1. Summary of the Tests Conducted for the 1 in. Riprap with 2 in. Thickness

Discharge Q cfs	Run #	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	Water temp. F	Area washed sq. ft	Test duration hrs
25	$ 1	0.00367	2.57	1.273	0.40	74		3.5
	$ 2	0.00490	3.55	0.906	0.66	74		2.5
	$ 3	0.00617	3.87	0.846	0.74	72		3.0
	$ 4	0.00749	4.22	0.745	0.86	72		3.0
	$ 5	0.00872	4.45	0.714	0.93	74	2	2.5
	f$ 6	0.01012	4.59	0.689	0.97	74	23	2.5
	*$ 7	0.00869	4.77	0.714	0.99	74		4.0
50	$ 8	0.00220	3.76	1.703	0.51	74		2.5
	$ 9	0.00269	4.12	1.519	0.59	75		2.0
	$10	0.00334	No data collected because of power failure					1.7
	$11	0.00481	4.62	1.305	0.71	74	40	2.0
	$12	0.00317	4.22	1.432	0.62	74		4.0
	28	0.00409	3.85	1.336	0.58	71		2.0
	29	0.00490	4.30	1.262	0.67	71		2.0
	30	0.00561	4.76	1.252	0.75	72	0.03	2.3
	* 31	0.00561	5.06	1.262	0.79	72		4.0
75	$13	0.00239	Test was repeated because of low tailwater depth.					
	$14	0.00239	4.48	2.098	0.55	74		2.0
	$15	0.00288	4.70	2.009	0.58	68	0.7	2.0
	$16	0.00340	4.90	1.891	0.63	74	25	2.0
	$17	0.00281	4.64	1.970	0.58	70		3.5
	$18	0.00281	4.63	1.966	0.58	74	13	2.0
	19	0.00281	No data collected because of power failure					2.0
	20	0.00284	5.03	2.018	0.62	68		2.0
	21	0.00333	5.14	1.886	0.66	71		2.0
	f 22	0.00407	4.64	1.802	0.61	67	12	2.0
	* 23	0.00343	5.02	1.885	0.64	71		4.0
100	24	0.00225	4.86	2.479	0.54	68		2.0
	25	0.00266	4.62	2.397	0.53	70		2.0
	f 26	0.00308	5.15	2.286	0.60	72	2	2.0
	* 27	0.00318	5.06	2.337	0.58	70	0.7	3.5

f Failure of riprap
* Incipient failure conditions
$ The slope of the transition section was 1.75% more than that of the test section (see Chapter 3).

Table A-2. Summary of the Tests Conducted for the 1 in. Riprap with 2 in. Thickness (After removing flat rocks)

Discharge Q cfs	Run #	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number F	Water temp. °F	Area washed sq. ft	Test duration hrs
25	33	0.00998	4.40	0.684	0.94	70		2.0
	34	0.01088	4.51	0.703	0.95	68		4.0
	35	0.01186	4.72	0.672	1.01	68		2.0
	f 36	0.01337	4.95	0.618	1.11	68	7.2	2.0
	* 37	0.01204	4.77	0.651	1.04	68	2.7	4.0
50	f 32	0.00558	4.90	1.300	0.76	70	10.8	5.0
	* 41	0.00475	4.71	1.353	0.71	62	2.5	2.5
75	f 38	0.00402	5.02	1.832	0.65	63	0.4	2.0
	f 39	0.00377	5.00	1.842	0.65	69	0.1	2.0
	* 40	0.00345	4.84	1.918	0.62	72		4.0
100	42	0.00314	4.97	2.371	0.57	68		2.5
	43	0.00403	4.90	2.415	0.56	66		1.8
	f 44	0.00436	5.20	2.210	0.62	63	17.7	2.0
	* 45	0.00354	5.09	2.332	0.59	72	2.5	4.0

* Incipient failure condition

f Failure Conditions

Table A-3. Summary of the Tests Conducted for the 1 in. Riprap with 3 in. Thickness

Discharge Q cfs	Run #	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	Water temp. °F	Area washerd sq. ft	Test duration hrs
25	46	0.00880	4.37	0.720	0.91	66		2.0
	47	0.01011	4.61	0.688	0.98	69		2.0
	48	0.01313	5.02	0.640	1.11	68		2.0
	* 57	0.01475	5.02	0.625	1.12	64		4.5
	f 58	0.01626	5.52	0.568	1.29	67	23	3.0
50	49	0.00526	4.94	1.268	0.77	70		2.0
	50	0.00636	5.36	1.169	0.87	68		3.5
	51	0.00726	5.61	1.102	0.94	68	4.6	3.3
	52	0.00726	5.74	1.906	0.73	63		2.7
	f 53	0.00802	5.66	1.095	0.95	58	37.4	2.0
	f 54	0.00732	5.64	1.111	0.94	64	23	1.7
	f 55	0.00732	5.03	1.245	0.79	65	3.7	4.3
	* 56	0.00647	5.11	1.231	0.81	67		4.0
75	59	0.00423	4.90	1.907	0.63	68		3.0
	* 60	0.00517	5.11	1.814	0.67	72		3.0
	f 61	0.00621	5.50	1.714	0.74	73	49.5	2.0
100	62	0.00406	4.63	2.513	0.51	75		2.5
	f 63	0.00457	5.25	2.210	0.62	67	2	2.5
	* 64	0.00409	5.10	2.298	0.59	65		3.0

* Incipient failure conditions

f Failure conditions

Table A-4. Summary of the Tests Conducted for the 2 in. Riprap with 4 in. Thickness

Discharge Q cfs	Run #	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	water temp. °F	Area washed sq. ft	Test duration hrs
25	76	0.01193	4.55	0.681	0.97	67		3.0
	77	0.01858	5.27	0.598	1.20	67		1.5
50	65	0.00998	5.03	1.246	0.79	68		2.8
	66	0.01378	6.13	1.019	1.07	75		2.0
	* 67	0.01519	6.36	0.987	1.13	72		1.7
	68	0.01796	6.71	0.935	1.22	72		3.3
	f 69	0.01888	6.63	0.948	1.20	68	59.8	1.7
	f 78	0.01579	6.14	1.022	1.07	68	5.5	1.7
75	f 70	0.01110	6.65	1.410	0.99	69	64.1	0.8
	71	0.00781	6.33	1.483	0.92	70		2.5
	* 72	0.00937	6.81	1.423	1.01	70		2.0
100	73	0.00731	6.43	1.954	0.81	72		2.5
	* 74	0.00840	6.62	1.891	0.85	71		3.0
	f 75	0.01066	7.00	1.804	0.92	70	27	2.3

* Incipient failure conditions

f Failure conditions

Table A-5. Summary of the Tests Conducted for the 2 in. Riprap with 6 in. Thickness

Discharge Q cfs	Run #	Flume slope S	Average velocity V, fps	Average depth D, ft	Froude number F	water temp. °F	Area washed sq. ft	Test duration hrs
25	79	0.01180	4.42	0.710	0.92	68		2.0
	80	0.01870	5.17	0.607	1.17	69		2.0
50	81	0.01205	5.90	1.068	1.01	70		2.0
	82	0.01544	6.47	0.966	1.16	67		2.7
	83	0.01724	6.76	0.928	1.24	67		1.5
	* 84	0.01879	6.61	0.970	1.18	68		2.0
75	85	0.00898	6.19	1.519	0.89	72		1.7
	86	0.01095	6.58	1.414	0.98	72		1.5
	87	0.01206	6.63	1.423	0.98	73		1.5
	* 88	0.01359	6.88	1.372	1.04	73		2.0
	f 89	0.01565	6.84	1.399	1.02	75	9.6	2.3
100	90	0.00866	6.97	1.808	0.91	77		2.3
	91	0.00938	6.96	1.796	0.92	77		1.3
	92	0.01084	7.39	1.711	1.00	77		2.0
	* 93	0.01189	7.44	1.698	1.01	75		2.3
	f 94	0.01300	8.02	1.572	1.13	75	15	1.3

* Incipient failure conditions
f Failure conditions

APPENDIX B

VELOCITY DATA

CORPS OF ENGINEERS RIPRAP PROJECT

Q=25 cfs Rock size 1 in. Thickness 2 in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 1	110	4.0	1.25	0.80	3.09
S=0.00872				0.20	2.13
	125	4.0	1.26	0.80	2.91
				0.20	2.33
	140	4.0	1.32	0.80	3.04
				0.20	1.94
Run # 2	110	4.0	0.89	0.80	4.20
S=0.00490				0.20	3.18
	125	4.0	0.89	0.80	4.23
				0.20	2.94
	140	4.0	0.94	0.80	4.06
				0.20	2.70
Run # 3	110	4.0	0.82	0.80	4.50
S=0.00617				0.20	3.32
	125	4.0	0.84	0.80	4.54
				0.20	3.35
	140	4.0	0.89	0.80	4.33
				0.20	3.18
Run # 4	110	4.0	0.75	0.80	4.81
S=0.00749				0.20	3.32
	125	4.0	0.78	0.80	4.88
				0.20	3.62
	140	4.0	0.86	0.80	4.98
				0.20	3.72
Run # 5	110	4.0	0.71	0.80	5.18
S=0.00872				0.20	4.06
	125	4.0	0.71	0.80	5.29
				0.20	3.28
	140	4.0	0.72	0.80	5.29
				0.20	3.62
Run # 6	110	4.0	0.72	0.80	5.15
S=0.01012				0.20	3.59
	125	4.0	0.65	0.80	5.59
				0.20	4.06
	140	4.0	0.69	0.80	5.46
				0.20	3.69

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 7 S=0.00845 Rock size 1 in.
Q=25 cfs Temp. 74 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=110'	0.90	0.64	4.57	5.46	5.15
D=0.715'	0.70	0.50	5.32	5.25	4.91
	0.50	0.36	5.15	4.64	4.40
	0.30	0.21	4.47	4.00	3.76
X=125'	0.90	0.63	5.66	5.46	4.98
D=0.703'	0.70	0.49	5.35	5.12	4.98
	0.50	0.35	4.67	4.64	4.57
	0.30	0.21	4.06	4.03	3.93
X=140'	0.90	0.65	5.35	5.42	5.32
D=0.724'	0.70	0.51	5.05	5.05	5.01
	0.50	0.36	4.64	4.67	4.50
	0.30	0.22	4.10	4.00	3.89

CORPS OF ENGINEERS RIPRAP PROJECT

Q=50 cfs   Rock size 1 in.   Thickness 2 in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 8	110	4.00	1.70	0.80	4.44
S=0.00220				0.20	3.08
	125	4.00	1.70	0.80	4.30
				0.20	3.28
	140	4.00	1.71	0.08	4.40
				0.02	3.08
Run # 9	110	4.00	1.51	0.80	5.15
S=0.00269				0.20	3.25
	125	4.00	1.52	0.80	4.67
				0.20	3.55
	140	4.00	1.52	0.80	4.78
				0.20	3.32
Run # 10	110	4.00	1.42	0.80	5.05
S=0.00334				0.20	3.62
	125	4.00	1.46	0.80	4.61
				0.20	
Run # 11	110	4.00	1.37	0.80	5.05
S=0.00481				0.20	3.96
	125	4.00	1.26	0.80	4.71
				0.20	4.37
	140	4.00	1.29	0.80	5.25
				0.20	4.40

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 12 S=0.00317 Rock size 1 in.
Q=50 cfs Temp 74 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=110'	0.90	1.26	5.49	5.49	3.93
D=1.404'	0.70	0.98	5.35	4.91	4.20
	0.50	0.70	4.98	4.61	4.13
	0.30	0.42	4.37	3.79	3.83
	0.10	0.14	3.01	3.04	2.84
X=125'	0.90	1.29	5.14	5.01	4.06
D=1.435'	0.70	1.00	5.19	4.78	4.33
	0.50	0.72	4.95	4.57	4.13
	0.30	0.43	4.33	3.96	3.83
	0.10	0.14	3.04	2.87	2.81
X=140'	0.90	1.31	4.98	5.12	4.40
D=1.458'	0.70	1.02	5.12	4.78	4.64
	0.50	0.73	4.71	4.40	4.44
	0.30	0.44	4.06	3.93	3.72
	0.10	0.15	3.04	2.94	2.67

CORPS OF ENGINEERS RIPRAP PROJECT

Q=75 cfs . Rock size 1 in. Thickness 2 in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 13	110	4.00	2.11	0.80	5.35
S=0.00239				0.20	3.49
	125	4.00	2.07	0.80	5.35
				0.20	3.93
	140	4.00	2.06	0.08	5.49
				0.02	4.23
Run # 14	110	4.00	2.09	0.80	5.25
S=0.00239				0.20	3.79
	125	4.00	2.10	0.80	5.12
				0.20	3.76
	140	4.00	2.10	0.80	5.22
				0.20	3.76
Run # 15	110	4.00	2.06	0.80	5.35
S=0.00288				0.20	3.50
	125	4.00	1.98	0.80	5.86
				0.20	4.00
	140	4.00	1.99	0.80	5.52
				0.20	3.96
Run # 16	110	4.00	1.88	0.80	6.07
S=0.00340				0.20	3.69
	125	4.00	1.91	0.80	5.69
				0.20	4.13
	140	4.00	1.88	0.80	5.73
				0.20	4.10

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 17	S=0.00281	Rock size 1 in.
Q=75 cfs	Temp. 70 F	Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=110'	0.90	1.79	5.39	5.69	4.37
D=1.985'	0.70	1.39	5.49	5.25	5.05
	0.50	0.99	5.29	4.74	5.09
	0.30	0.60	4.47	4.06	4.61
	0.10	0.20	3.01	2.91	3.18
X=125'	0.90	1.74	5.52	6.00	4.60
D=1.930'	0.70	1.35	5.42	5.46	5.08
	0.50	0.97	5.01	5.01	4.95
	0.30	0.58	4.74	4.40	4.57
	0.10	0.19	3.66	2.98	3.42
X=140'	0.90	1.80	5.22	5.62	4.37
D=1.996	0.70	1.40	5.49	5.52	4.74
	0.50	1.00	5.15	4.95	4.78
	0.30	0.60	4.74	4.44	4.13
	0.10	0.20	3.69	3.32	3.15

CORPS OF ENGINEERS RIPRAP PROJECT

Q=75 cfs Rock size 1 in. Thickness 2 in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 18	110	4.00	1.98	0.80	5.42
S=0.00281				0.20	3.38
	125	4.00	1.94	0.80	5.69
				0.20	3.69
	140	4.00	1.98	0.08	5.52
				0.02	3.79
Run # 20	120	4.00	2.01	0.80	5.93
S=0.00284				0.20	4.37
	130	4.00	2.02	0.80	5.76
				0.20	4.20
	140	4.00	2.02	0.80	5.86
				0.20	4.06
Run # 21	120	4.00	1.87	0.80	6.10
S=0.00333				0.20	3.86
	130	4.00	1.90	0.80	6.03
				0.20	4.30
	140	4.00	1.89	0.80	6.20
				0.20	4.30
Run # 22	120	4.00	1.81	0.80	5.79
S=0.00407				0.20	3.51
	130	4.00	1.79	0.80	5.56
				0.20	3.52
	140	4.00	1.81	0.80	5.74
				0.20	3.69

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 23	S=0.00343	Rock size 1 in.
Q=75 cfs	Temp. 71 F	Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	1.69	5.39	6.44	5.49
D=1.880'	0.70	1.32	5.73	6.13	5.59
	0.50	0.94	5.39	5.49	5.42
	0.30	0.56	4.84	4.78	4.67
	0.10	0.19	3.21	3.59	3.52
X=130'	0.90	1.69	5.32	6.13	5.52
D=1.883'	0.70	1.32	5.57	5.73	5.42
	0.50	0.94	5.49	5.46	5.29
	0.30	0.56	4.57	4.91	4.74
	0.10	0.19	3.49	3.35	3.52
X=140'	0.90	1.70	5.42	6.17	5.59
D=1.892'	0.70	1.32	5.59	5.96	5.66
	0.50	0.95	5.39	5.66	5.49
	0.30	0.57	4.71	4.88	4.71
	0.10	0.19	3.49	3.59	3.38

CORPS OF ENGINEERS RIPRAP PROJECT

Q=100 cfs Rock size 1 in. Thickness 2in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 24	120	4.00	2.48	0.80	5.79
S=0.00225				0.20	3.93
	130	4.00	2.47	0.80	5.79
				0.20	3.83
	140	4.00	2.49	0.08	5.69
				0.02	4.13
Run # 25	120	4.00	2.39	0.80	5.66
S=0.00266				0.20	3.69
	130	4.00	2.39	0.80	5.39
				0.20	3.72
	140	4.00	2.41	0.80	5.35
				0.20	3.93
Run # 26	120	4.00	2.28	0.80	6.41
S=0.00308				0.20	4.13
	130	4.00	2.28	0.80	6.10
				0.20	4.05
	140	4.00	2.30	0.80	6.07
				0.20	4.13

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 27 S=0.00318 Rock size 1 in.
Q=100 cfs Temp 70 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	2.10	5.46	5.93	5.66
D=2.328'	0.70	1.63	5.81	5.22	5.93
	0.50	1.16	5.62	4.84	5.81
	0.30	0.70	5.05	4.44	5.13
	0.10	0.23	3.66	3.15	3.66
X=130'	0.90	2.10	5.61	6.20	6.00
D=2.334'	0.70	1.63	5.90	5.81	6.17
	0.50	1.17	5.62	5.04	5.95
	0.30	0.70	4.85	4.44	5.09
	0.10	0.23	3.80	3.26	3.69
X=140'	0.90	2.11	5.48	5.69	5.84
D=2.348'	0.70	1.64	5.73	5.56	6.03
	0.50	1.17	5.62	4.95	5.62
	0.30	0.70	4.80	4.54	5.12
	0.10	0.23	3.50	3.10	3.07

CORPS OF ENGINEERS RIPRAP PROJECT

Q=50 cfs Rock size 1 in. Thickness 2 in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 28	120	4.00	1.37	0.80	4.87
S=0.00409				0.20	2.73
	130	4.00	1.39	0.80	4.90
				0.20	3.00
	140	4.00	1.40	0.08	4.74
				0.02	2.77
Run # 29	120	4.00	1.26	0.80	5.25
S=0.00490				0.20	3.20
	130	4.00	1.25	0.80	5.32
				0.20	3.31
	140	4.00	1.27	0.80	5.52
				0.20	3.21
Run # 30	120	4.00	1.25	0.80	5.59
S=0.00561				0.20	4.06
	130	4.00	1.25	0.80	5.72
				0.20	3.72
	140	4.00	1.26	0.80	5.62
				0.20	3.76

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 31	S=0.00561	Rock size 1 in.	
Q=50 cfs	Temp. 72 F	Thickness 2 in.	

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	1.13	5.99	6.00	5.93
D=1.250'	0.70	0.88	6.07	5.46	5.90
	0.50	0.63	5.59	5.11	5.46
	0.30	0.38	4.91	4.44	4.50
	0.10	0.13	3.72	3.11	3.35
X=130'	0.90	1.14	6.10	5.96	5.90
D=1.269'	0.70	0.89	5.93	5.49	5.96
	0.50	0.63	5.52	5.05	5.46
	0.30	0.38	4.64	4.37	4.88
	0.10	0.13	3.55	3.04	3.35
X=140'	0.90	1.14	6.00	6.00	6.07
D=1.268	0.70	0.89	6.03	5.66	6.10
	0.50	0.63	5.62	5.05	5.66
	0.30	0.38	5.02	4.52	5.08
	0.10	0.13	3.45	3.23	3.42

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 32	S=0.005575	Rock size 1 in.
Q=50 cfs	Temp. 70 F	Thickness 2 in.

	Fraction of Depth	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=2.67'	Velocity ft/sec Y=4.00'	Velocity ft/sec Y=5.32'	Velocity ft/sec Y=6.67'
X=120'	0.90	5.76	6.10	5.85	6.30	5.88
D=1.302'	0.70	5.92	5.96	5.68	5.95	5.83
	0.50	5.59	5.39	5.12	5.63	5.39
	0.30	4.84	4.88	4.17	4.83	4.70
	0.10	3.11	3.63	3.25	3.58	3.42
X=125'	0.90	6.07		5.73		5.62
D=1.300'	0.70	5.93		5.46		5.73
	0.50	5.49		5.08		5.18
	0.30	4.74		4.23		4.47
	0.10	3.38		3.28		3.15
X=130'	0.90	5.73	5.76	5.86	6.06	5.66
D=1.267'	0.70	5.70	5.52	5.35	5.86	5.66
	0.50	5.25	5.25	4.84	5.42	5.12
	0.30	4.27	4.54	4.20	4.54	4.47
	0.10	3.25	3.28	3.18	3.32	3.25
The Following Data Collected After Readjustment of The Depth.						
X=125'	0.90			5.87		
D=1.292'	0.70			5.52		
	0.50			5.22		
	0.30			4.33		
	0.10			2.96		
X=130'	0.90		6.07	5.90		
D=1.281'	0.70		5.86	5.60		
	0.50		5.46	5.01		
	0.30		4.78	4.40		
	0.10		3.25	3.21		

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 33		S=0.00998		Rock size 1 in.	
Q=25 cfs		Temp. 70 F		Thickness 2 in.	
	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.55	5.18	5.25	5.52
D=0.692'	0.20	0.14	3.42	3.42	3.83
X=130'	0.80	0.54	5.35	5.32	5.83
D=0.680'	0.20	0.14	3.38	3.52	3.62
X=140'	0.80	0.54	4.98	5.29	5.22
D=0.678'	0.20	0.14	3.25	3.59	3.25

Run # 34		S=0.01088		Rock size 1 in.	
Q=25 cfs		Temp. 68 F		Thickness 2 in.	
	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.56	5.25	5.25	5.64
D=0.703'	0.20	0.14	3.38	3.72	3.69
X=130'	0.80	0.56	5.49	5.49	5.93
D=0.699'	0.20	0.14	3.52	3.65	3.60
X=140'	0.80	0.57	5.29	5.45	5.22
D=0.707'	0.20	0.14	3.38	3.35	3.59

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 35		S=0.01186		Rock size 1 in.	
Q=25 cfs		Temp. 68 F		Thickness 2 in.	
	Fraction of depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.53	5.42	5.59	6.03
D=0.665'	0.20	0.13	3.18	3.38	3.96
X=130'	0.80	0.54	5.59	5.76	6.02
D=0.679'	0.20	0.14	3.79	3.69	4.06
X=140'	0.80	0.54	5.35	5.73	5.86
D=0.673'	0.20	0.13	3.11	4.03	4.33

Run # 36		S=0.01337		Rock size 1 in.	
Q=25 cfs		Temp. 68 F		Thickness 2 in.	
	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.50	5.56	5.62	6.03
D=0.630'	0.20	0.13	3.59	3.76	3.96
X=130'	0.80	0.49	6.13	6.13	6.44
D=0.610'	0.20	0.12	4.17	4.47	4.33
X=140'	0.80	0.49	5.59	6.10	5.59
D=0.614'	0.20	0.12	3.72	4.10	3.79

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 37	S=0.01204	Rock size 1 in.
Q=25 cfs	Temp. 68 F	Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	0.59	5.52	5.76	6.03
D=0.657'	0.70	0.46	5.18	5.46	5.57
	0.50	0.33	4.61	4.84	4.98
	0.30	0.20	3.76	4.20	4.37
	0.15	0.10	3.11	3.35	3.83
X=130'	0.90	0.58	5.56	5.90	5.93
D=0.645'	0.70	0.45	5.15	5.51	5.52
	0.50	0.32	4.57	4.91	5.05
	0.30	0.19	3.89	4.20	4.27
	0.22	0.14	3.49	3.79	3.89
X=140'	0.90	0.59	5.86	5.96	5.82
D=0.650'	0.70	0.46	5.25	5.21	5.15
	0.50	0.33	4.91	5.22	4.88
	0.30	0.20	4.33	4.44	4.23
	0.20	0.13	3.76	3.79	3.66

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 38 S=0.00402 Rock size 1 in.
Q=75 cfs Temp 63 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	1.47	5.56	6.07	5.56
D=1.841'	0.20	0.37	4.30	4.27	4.27
X=130'	0.80	1.45	5.59	6.17	5.79
D=1.815'	0.20	0.36	4.10	4.30	4.23
X=140'	0.80	1.47	5.59	6.10	5.73
D=1.840'	0.20	0.37	4.10	4.27	4.30

Run # 39 S=0.00377 Rock size 1 in.
Q=75 cfs Temp. 69 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	1.46	5.50	6.24	5.66
D=1.819'	0.20	0.36	4.13	4.54	4.13
X=130'	0.80	1.45	5.59	5.97	5.63
D=1.815'	0.20	0.36	4.27	4.20	4.98
X=140'	0.80	1.48	5.59	6.07	5.63
D=1.856'	0.20	0.37	4.13	4.34	5.01

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 40	S=0.00330	Rock size 1 in.
Q=75 cfs	Temp 72 F	Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	1.72	5.25	6.17	5.25
D=1.907'	0.70	1.33	5.42	5.76	5.46
	0.50	0.95	5.22	5.15	5.15
	0.30	0.57	4.57	4.50	4.47
	0.10	0.19	3.49	3.49	3.38
X=130'	0.90	1.72	5.35	6.10	5.29
D=1.906'	0.70	1.33	5.52	5.76	5.39
	0.50	0.95	5.22	5.25	5.01
	0.30	0.57	4.61	4.74	4.37
	0.10	0.19	3.59	3.66	3.15
X=140'	0.90	1.75	5.21	6.07	5.18
D=1.942'	0.70	1.36	5.52	5.62	5.32
	0.50	0.97	5.05	5.29	4.95
	0.30	0.58	4.61	4.78	4.54
	0.10	0.19	3.11	3.55	3.45

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 41	S=0.00475	Rock size 1 in.
Q=50 cfs	Temp. 62 F	Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	1.23	5.62	5.49	5.49
D=1.364'	0.70	0.95	5.56	5.18	5.56
	0.50	0.68	5.15	4.67	5.19
	0.30	0.41	4.50	3.96	4.57
	0.10	0.14	3.38	2.87	3.35
X=130'	0.90	1.20	5.66	5.56	5.46
D=1.338'	0.70	0.94	5.66	5.25	5.56
	0.50	0.67	5.18	4.74	5.18
	0.30	0.40	4.74	3.93	4.50
	0.10	0.13	3.21	3.11	3.04
X=140'	0.90	1.22	5.62	5.29	5.49
D=1.356'	0.70	0.95	5.66	5.32	5.56
	0.50	0.68	5.18	4.84	5.35
	0.30	0.41	4.44	4.17	4.57
	0.10	0.14	3.11	2.67	3.28

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 42 Q=100 cfs		S=0.00314 Temp 68 F		Rock size 1 in. Thickness 2 in.	
	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120' D=2.424'	0.80 0.20	1.94 0.48	5.59 4.30	5.52 3.76	6.02 4.57
X=130' D=2.308'	0.80 0.20	1.85 0.46	5.76 4.61	5.32 3.96	6.00 4.84
X=140' D=2.380'	0.80 0.20	1.90 0.48	5.59 4.17	5.52 3.96	6.03 4.71

Run # 43 Q=100 cfs		S=0.00403 Temp. 66 F		Rock size 1 in. Thickness 2 in.	
	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120' D=2.448'	0.80 0.20	1.96 0.49	5.18 4.27	5.62 4.00	5.66 4.23
X=130' D=2.355'	0.80 0.20	1.88 0.47	5.52 4.13	5.90 4.03	5.97 4.47
X=140' D=2.441'	0.80 0.20	1.95 0.49	5.29 4.30	5.79 3.85	5.59 4.44

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 44 S=0.00436 Rock size 1 in.
Q=100 cfs Temp. 63 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.00'	Velocity ft/sec Y=6.67'
X=120'	0.80	1.76	5.86	6.30	6.27
D=2.194'	0.20	0.44	4.23	4.27	4.54
X=130'	0.80	1.78	5.76	6.10	6.13
D=2.223'	0.20	0.44	4.03	3.89	4.27
X=140'	0.80	1.77	5.90	6.37	6.07
D=2.213'	0.20	0.44	4.54	4.37	4.64

Run # 45 S=0.00354 Rock size 1 in.
Q=100 cfs Temp 72 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	2.10	5.69	5.73	6.00
D=2.337'	0.70	1.64	5.62	5.33	6.07
	0.50	1.17	5.52	4.91	6.00
	0.30	0.70	4.88	4.52	5.12
	0.10	0.23	3.66	3.38	3.92
X=130'	0.90	2.04	5.52	6.24	6.37
D=2.272'	0.70	1.59	5.76	5.59	6.20
	0.50	1.14	5.52	5.05	6.00
	0.30	0.68	4.71	4.47	5.12
	0.10	0.23	3.66	3.52	4.00
X=140'	0.90	2.15	5.29	5.56	5.73
D=2.387'	0.70	1.67	5.52	5.35	5.96
	0.50	1.19	5.46	4.82	5.83
	0.30	0.72	4.78	4.40	5.22
	0.10	0.24	3.52	3.66	3.76

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 46 S=0.00888 Rock size 1 in.
Q=25 cfs Temp. 66 F Thickness 3 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.57	5.46	5.25	5.46
D=0.712'	0.20	0.14	3.32	3.42	3.52
X=130'	0.80	0.56	5.35	5.29	5.35
D=0.702'	0.20	0.14	3.62	3.52	3.89
X=140'	0.80	0.60	5.35	5.22	5.29
D=0.746'	0.20	0.15	3.55	3.55	3.52

Run # 47 S=0.01011 Rock size 1 in.
Q=25 cfs Temp 69 F Thickness 3 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.55	5.69	5.49	5.83
D=0.682'	0.20	0.14	3.35	3.49	3.45
X=130'	0.80	0.53	5.46	5.59	5.42
D=0.664'	0.20	0.13	3.79	3.76	3.72
X=140'	0.80	0.58	5.56	5.56	5.39
D=0.719'	0.20	0.14	3.59	3.45	3.72

Run # 48 S=0.01313 Rock size 1 in.
Q=25 cfs Temp 68 F Thickness 3 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.50	6.27	6.04	6.14
D=0.622'	0.20	0.12	3.80	4.20	4.20
X=130'	0.80	0.49	5.87	6.13	5.70
D=0.618'	0.20	0.12	3.72	2.98	3.69
X=140'	0.80	0.54	5.97	6.14	5.77
D=0.679'	0.20	0.14	4.10	4.27	3.76

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 49 S=0.00526 Rock size 1 in.
Q=50 cfs Temp 70 F Thickness 3 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y=6.67'
X=120'	0.80	1.02	6.11	5.59	6.00
D=1.281'	0.20	0.26	4.49	3.76	4.27
X=130'	0.80	1.00	6.00	5.63	6.04
D=1.253'	0.20	0.25	4.58	4.03	4.20
X=140'	0.80	1.02	5.90	5.56	6.00
D=1.270	0.20	0.25	4.24	3.86	4.14

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 50	S=0.00636	Rock size 1 in.
Q=50 cfs	Temp 68 F	Thickness 3 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.90	1.06		6.30	
D=1.178'	0.80	0.94	6.24		6.20
	0.70	0.82		5.93	
	0.50	0.59		5.39	
	0.40	0.47		4.98	
	0.30	0.35		4.47	
	0.20	0.24	4.03		4.00
	0.11	0.13		3.38	
X=130'	0.80	0.92	6.37	6.07	6.27
D=1.146'	0.20	0.23	4.37	4.00	4.23
X=140'	0.80	0.95	6.17	5.90	6.30
D=1.184'	0.20	0.24	4.44	4.13	4.10

The Folowing Velocity Data Collected Using a Pitot Tube

	Fraction of Depth	Velocity ft/sec X=120' D=1.178'	Velocity ft/sec X=130' D=1.146'	Velocity ft/sec X=140' D=1.184'
Y=4.0'	0.90	6.47	6.71	6.42
	0.70	6.34	6.30	6.04
	0.50	5.67	5.90	5.57
	0.40	5.38	5.53	5.43
	0.30	5.02	5.33	4.80
	0.20	4.69	4.51	4.45
	0.15	4.33	4.27	4.33
	0.10	3.95	4.01	3.66
	0.05	3.66	3.51	3.02

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 51	S=0.00726	Rock size 1 in.
Q=50 cfs	Temp 68 F	Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.637	0.90	0.93		6.80	
D=1.113'	71.458	0.70	0.75		6.30	
	71.244	0.50	0.54		5.90	
	71.137	0.40	0.43		5.60	
	71.030	0.30	0.32		5.20	
	70.922	0.20	0.21		4.90	
	70.869	0.15	0.16		4.60	
	70.815	0.10	0.11		4.10	
	70.762	0.05	0.05		3.10	
*		0.80	0.89	6.58	6.23	6.34
*		0.20	0.22	4.21	3.88	4.33
X=130'	71.67	0.90	0.97		6.50	
D=1.083'	71.46	0.70	0.76		6.00	
	71.24	0.50	0.54		5.60	
	71.13	0.40	0.43		5.10	
	71.02	0.30	0.33		4.80	
	70.91	0.20	0.22		4.10	
	70.86	0.15	0.16		3.60	
	70.81	0.10	0.11		2.80	
	70.75	0.05	0.05		2.50	
*		0.80	0.87	6.55	6.71	6.98
*		0.20	0.22	4.60	4.51	4.71
X=140'	71.70	0.90	1.00		6.50	
D=1.109'	71.48	0.70	0.78		6.10	
	71.26	0.50	0.56		5.50	
	71.15	0.40	0.44		5.10	
	71.03	0.30	0.33		4.90	
	70.92	0.20	0.22		4.50	
	70.87	0.15	0.17		4.10	
	70.81	0.10	0.11		3.70	
	70.76	0.05	0.06		3.30	
*		0.80	0.89	6.90	6.59	6.99
*		0.20	0.22	4.58	4.73	4.48

* Velocity Data Collected Using an Ott Meter

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 52		S=0.00726		Rock size 1 in.	
Q=50 cfs		Temp 63 F		Thickness 3 in	
	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.89	6.51	6.25	6.77
D=1.118'	0.20	0.22	4.36	5.36	4.47
X=130'	0.80	0.87	6.56	6.40	6.75
D=1.085'	0.20	0.22	4.29	4.33	4.89
X=140'	0.80	0.87	6.73	6.50	6.73
D=1.084'	0.20	0.22	4.81	4.01	4.65

CORPS OF ENGINEERS RIPRAP PROJECT

	Run # 54		S=0.00732		Rock size 1 in.	
	Q=50 cfs		Temp 63 F		Thickness 3 in.	
	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocitv ft/sec Y =6.67'
X=120'	71.71	0.90	1.00	6.75	6.63	6.83
D=1.111'	71.49	0.70	0.78	6.34	6.22	6.55
	71.27	0.50	0.56	5.63	5.48	6.13
	71.16	0.40	0.44	5.28	4.97	5.67
	71.05	0.30	0.33	4.63	4.63	5.13
	70.93	0.20	0.22	4.21	4.33	4.80
	70.88	0.15	0.17	3.88	4.08	4.63
	70.82	0.10	0.11	3.51	3.74	4.33
	70.77	0.05	0.05	3.19	2.54	3.59

Test stop d due to power failure

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 55	S=0.00732	Rock size 1 in.
Q=50 cfs	Temp 65 F	Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.75	0.90	1.04	6.39	6.47	6.67
D=1.151'	71.52	0.70	0.81	6.04	5.95	6.39
	71.29	0.50	0.58	5.48	5.38	5.58
	71.17	0.40	0.46	5.18	5.02	5.33
	71.06	0.30	0.34	4.86	4.46	4.91
	70.94	0.20	0.23	4.01	4.01	4.14
	70.89	0.15	0.17	3.74	3.51	3.74
	70.83	0.10	0.11	3.28	2.93	3.28
	70.77	0.05	0.06	2.54	1.94	2.07
	70.66			1.27		
	70.69				1.79	
	70.67					1.27
X=130'	71.67	0.90	0.97	6.55	6.75	6.59
D=1.078'	71.46	0.70	0.75	6.30	6.22	6.43
	71.24	0.50	0.54	5.77	5.67	5.72
	71.13	0.40	0.43	5.43	5.18	5.38
	71.03	0.30	0.32	5.08	4.63	5.13
	70.92	0.20	0.22	4.52	4.01	4.52
	70.86	0.15	0.16	4.08	3.66	4.21
	70.81	0.10	0.11	3.81	2.93	3.95
	70.76	0.05	0.05	2.64	2.74	3.44
	70.66			1.26		
	70.74				2.54	
	70.62					1.79
X=140'	71.73	0.90	1.03	6.39	6.55	6.51
D=1.147'	71.50	0.70	0.80	6.13	6.00	6.39
	71.27	0.50	0.57	5.67	5.38	5.91
	71.16	0.40	0.46	5.18	5.26	5.43
	71.04	0.30	0.34	4.52	5.72	4.91
	70.93	0.20	0.23	4.21	4.08	4.27
	70.87	0.15	0.17	3.81	3.88	3.81
	70.81	0.10	0.11	3.28	3.59	3.19
	70.76	0.05	0.06	2.84	2.84	2.07
	70.70			2.32		
	70.68				2.64	
						2.07

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 56	S=0.00647	Rock size 1 in.
Q=50 cfs	Temp 67 F	Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	71.86	0.90	1.11	6.47	6.04	6.28
D=1.236'	71.61	0.70	0.87	6.28	5.51	6.24
	71.36	0.50	0.62	5.74	5.21	5.60
	71.24	0.40	0.49	5.43	4.72	5.42
	71.12	0.30	0.37	4.97	4.36	5.05
	70.99	0.20	0.25	4.40	3.98	4.40
	70.93	0.15	0.19	4.08	3.23	4.11
	70.87	0.10	0.12	3.40	3.02	3.36
	70.81	0.05	0.06	2.26	2.79	1.79
	70.72			1.04		
	70.72				0.90	
	70.73					0.10
X=130'	71.82	0.90	1.08	5.97	6.39	6.17
D=1.206'	71.58	0.70	0.84	5.86	5.91	6.09
	71.34	0.50	0.60	5.58	5.15	5.77
	71.22	0.40	0.48	5.26	4.86	5.53
	71.10	0.30	0.36	5.10	4.60	5.20
	70.98	0.20	0.24	4.72	4.36	4.78
	70.92	0.15	0.18	4.40	3.67	4.36
	70.86	0.10	0.12	4.08	3.36	4.11
	70.80	0.05	0.06	3.51	2.98	3.32
	70.73			2.32		
	70.67				2.00	
	70.66					0.00
X=140'	71.86	0.90	1.12	6.00	5.91	5.86
D=1.247'	71.61	0.70	0.87	5.84	5.65	5.86
	71.36	0.50	0.62	5.53	5.23	5.60
	71.23	0.40	0.50	5.08	4.78	5.28
	71.11	0.30	0.37	4.80	4.52	4.75
	70.98	0.20	0.25	4.27	3.98	4.43
	70.92	0.15	0.19	4.01	3.40	
	70.86	0.10	0.12	3.59	3.15	
	70.80	0.05	0.06	3.11	2.93	
	70.73			2.64		
	70.75				2.48	

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 57	S=0.01475	Rock size 1 in.
Q=25 cfs	Temp 64 F	Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	71.29	0.90	0.56	6.20	6.00	6.00
D=0.618'	71.17	0.70	0.43	5.80	5.20	5.30
	71.04	0.50	0.31	5.10	4.80	4.60
	70.98	0.40	0.25	4.50	4.30	4.10
	70.92	0.30	0.19	4.10	4.10	3.60
	70.86	0.20	0.12	3.90	3.30	3.40
	70.83	0.15	0.09	3.50	2.80	2.90
	70.80	0.10	0.06	3.30	2.40	2.70
	70.77	0.05	0.03	3.00	2.20	
	70.65			1.60		
	70.74				1.60	
	70.75					1.90
X=130'	71.28	0.90	0.56	6.10	6.20	6.30
D=0.625'	71.16	0.70	0.44	5.80	5.90	6.00
	71.03	0.50	0.31	5.40	5.50	5.30
	70.97	0.40	0.25	5.00	5.20	4.90
	70.91	0.30	0.19	4.80	4.70	4.50
	70.84	0.20	0.13	4.40	4.20	3.80
	70.81	0.15	0.09	3.80	3.80	3.10
	70.78	0.10	0.06	3.60	3.50	2.60
	70.75	0.05	0.03	3.40	3.10	2.20
	70.67			2.60		
	70.66				2.90	
	70.72					2.00
X=140'	71.28	0.90	0.57	6.08	6.26	6.13
D=0.632'	71.16	0.70	0.44	6.11	5.90	5.65
	71.03	0.50	0.32	5.70	5.40	5.12
	70.97	0.40	0.25	5.53	4.70	4.60
	70.91	0.30	0.19	5.02	4.30	4.30
	70.84	0.20	0.13	4.27	3.60	3.77
	70.81	0.15	0.09	3.88	3.10	3.36
	70.78	0.10	0.06	3.15	2.70	2.88
	70.75	0.05	0.03	3.11	2.30	
	70.69			2.43		
	70.74				2.43	
	70.69					0.89

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 58	S=0.01626	Rock size 1 in.
Q=25 cfs	Temp 67 F	Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.26	0.90	0.52	6.30	6.63	7.10
D=0.581'	71.14	0.70	0.41	6.04	6.17	6.41
	71.03	0.50	0.29	5.48	5.63	5.95
	70.97	0.40	0.23	5.28	5.28	5.28
	70.91	0.30	0.17	4.80	5.02	4.80
	70.85	0.20	0.12	4.33	4.57	4.21
	70.82	0.15	0.09	4.21	4.30	3.88
	70.79	0.10	0.06	3.88	3.95	3.59
	70.76	0.05	0.03	3.66	3.19	2.74
	70.74			3.11		
	70.68				0.00	
						1.55
X=130'	71.16	0.90	0.50	6.85	7.00	7.00
D=0.554'	71.05	0.70	0.39	6.50	6.80	6.60
	70.94	0.50	0.28	5.90	6.00	6.20
	70.89	0.40	0.22	5.70	5.70	6.00
	70.83	0.30	0.17	5.00	5.30	5.50
	70.78	0.20	0.11	4.10	4.70	5.30
	70.75	0.15	0.08	3.50	4.40	5.00
	70.72	0.10	0.06	3.20	3.90	4.90
	70.69	0.05	0.03	2.50	3.55	4.50
	70.66			2.60		
	70.66				2.88	
	70.58					2.80

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 59	S=0.00423	Rock size 1 in.
Q=75 cfs	Temp 68 F	Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.45	0.90	1.73		6.51	
D=1.919'	72.26	0.80	1.54	6.04		6.05
	72.07	0.70	1.34		6.19	
	71.68	0.50	0.96		5.53	
	71.49	0.40	0.77		5.33	
	71.30	0.30	0.58		4.94	
	71.11	0.20	0.38	4.46	4.52	4.97
	71.01	0.15	0.29		4.14	
	70.91	0.10	0.19		3.44	
	70.82	0.05	0.10		2.93	
	70.65				1.64	
X=130'	72.42	0.90	1.71		6.30	
D=1.900'	72.23	0.80	1.52	6.26		6.22
	72.04	0.70	1.33		6.22	
	71.66	0.50	0.95		5.48	
	71.47	0.40	0.76		5.33	
	71.28	0.30	0.57		4.97	
	71.09	0.20	0.38	4.40	4.52	4.91
	71.00	0.15	0.29		4.40	
	70.90	0.10	0.19		4.21	
	70.81	0.05	0.10		3.44	
	70.63				2.07	
X=140'	72.42	0.90	1.71		6.26	
D=1.902'	72.23	0.80	1.52	6.04		6.00
	72.04	0.70	1.33		6.22	
	71.66	0.50	0.95		6.00	
	71.47	0.40	0.76		5.43	
	71.28	0.30	0.57		5.02	
	71.09	0.20	0.38	4.57	4.57	4.63
	70.99	0.15	0.28		4.21	
	70.90	0.10	0.19		3.81	
	70.80	0.05	0.09		2.93	
	70.76				2.74	

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 60 S=0.00517 Rock size 1 in.
Q=75 cfs Temp 72 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	72.38	0.90	1.66		6.44	
D=1.847'	72.20	0.80	1.48	6.59		6.63
	72.02	0.70	1.29		6.08	
	71.65	0.50	0.92		5.53	
	71.46	0.40	0.74		4.85	
	71.28	0.30	0.55		4.74	
	71.09	0.20	0.37	4.91	4.07	5.02
	71.00	0.15	0.28		3.84	
	70.91	0.10	0.19		3.66	
	70.81	0.05	0.09		3.02	
	70.78				2.42	
X=130'	72.34	0.90	1.63	6.59	6.34	6.59
D=1.812'	71.98	0.70	1.27	6.34	6.04	6.44
	71.62	0.50	0.91	5.99	5.57	6.04
	71.44	0.40	0.72	5.76	5.12	5.76
	71.26	0.30	0.54	5.43	4.74	5.53
	71.07	0.20	0.36	4.96	4.33	4.91
	70.98	0.15	0.27	4.63	4.01	4.80
	70.89	0.10	0.18	4.20	3.80	4.27
	70.80	0.05	0.09	3.43	3.19	3.51
	70.71			1.15		
	70.73				2.31	
	70.73					2.31
X=140'	72.31	0.90	1.60		6.59	
D=1.782'	72.14	0.80	1.43	6.51		6.55
	71.96	0.70	1.25		6.21	
	71.60	0.50	0.89		5.72	
	71.42	0.40	0.71		5.33	
	71.24	0.30	0.53		4.91	
	71.07	0.20	0.36	5.07	4.39	5.12
	70.98	0.15	0.27		3.84	
	70.89	0.10	0.18		3.51	
	70.80	0.05	0.09		2.53	

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 61	S=0.00621	Rock size 1 in.
Q=75 cfs	Temp 73 F	Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.25	0.90	1.51		7.84	
D=1.676'	72.08	0.80	1.34	7.05		7.25
	71.91	0.70	1.17		7.34	
	71.58	0.50	0.84		6.55	
	71.41	0.40	0.67		6.26	
	71.24	0.30	0.50		5.74	
	71.07	0.20	0.34	4.72	5.02	5.26
	70.99	0.15	0.25		4.80	
	70.91	0.10	0.17		4.63	
	70.82	0.05	0.08		3.84	
	70.75			2.01		
	70.75				3.06	
	70.76					3.44
X=130'	72.41	0.90	1.68		6.67	
D=1.870'	72.22	0.80	1.50	5.95		6.09
	72.04	0.70	1.31		6.39	
	71.66	0.50	0.94		6.13	
	71.48	0.40	0.75		5.63	
	71.29	0.30	0.56		5.23	
	71.10	0.20	0.37	4.75	4.75	4.69
	71.01	0.15	0.28		3.95	
	70.91	0.10	0.19		3.88	
	70.82	0.05	0.09		3.51	
	70.74			1.27		
	70.77				1.79	
	70.75					1.27
X=140'	72.16	0.90	1.44		7.47	
D=1.597'	72.00	0.80	1.28	6.87		7.72
	71.84	0.70	1.12		7.14	
	71.52	0.50	0.80		6.59	
	71.36	0.40	0.64		6.17	
	71.20	0.30	0.48		6.00	
	71.04	0.20	0.32	5.13	5.33	5.58
	70.96	0.15	0.24		4.69	
	70.88	0.10	0.16		4.40	
	70.80	0.05	0.08		3.51	
	70.74			3.19		
	70.74				2.07	
	70.68					1.64

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 62	S=0.00406	Rock size 1 in.
Q=100 cfs	Temp 75 F	Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.95	0.90	2.21		5.81	
D=2.457'	72.70	0.80	1.97	5.81		6.22
	72.46	0.70	1.72		5.33	
	71.47	0.50	0.73		4.86	
	71.72	0.40	0.98		4.40	
	71.47	0.30	0.74		3.95	
	71.23	0.20	0.49		3.74	
	71.11	0.15	0.37	4.57	3.66	4.80
	70.98	0.10	0.25		3.19	
	70.86	0.05	0.12		2.84	
	70.68				1.27	
X=130'	72.99	0.90	2.27	5.43	5.91	5.91
D=2.519'	72.49	0.70	1.76	5.23	5.13	5.91
	71.99	0.50	1.26	5.48	4.86	5.77
	71.74	0.40	1.01	5.33	4.27	5.53
	71.48	0.30	0.76	5.02	4.14	5.28
	71.23	0.20	0.50	4.52	3.95	4.52
	71.11	0.15	0.38	4.08	3.51	4.14
	70.98	0.10	0.25	3.88	3.28	4.01
	70.85	0.05	0.13	3.19	2.64	3.11
	70.69			1.27		
	70.71				1.27	
	70.67					1.64
X=140'	73.03	0.90	2.31		5.48	
D=2.562'	72.77	0.80	2.05	5.48		5.72
	72.52	0.70	1.79		5.02	
	72.01	0.50	1.28		5.02	
	71.75	0.40	1.02		4.46	
	71.49	0.30	0.77		4.01	
	71.24	0.20	0.51	4.52	3.74	4.80
	71.11	0.15	0.38		3.59	
	70.98	0.10	0.26		3.28	
	70.85	0.05	0.13		2.64	
	70.73				1.47	

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 63 — S=0.00457 — Rock size 1 in.
Q=100 cfs — Temp 67 F — Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.70	0.90	1.98		6.75	
D=2.201'	72.48	0.80	1.76	5.95		6.55
	72.26	0.70	1.54		6.13	
	71.82	0.50	1.10		5.53	
	71.60	0.40	0.88		5.18	
	71.38	0.30	0.66		4.69	
	71.16	0.20	0.44	4.40	4.33	4.91
	71.05	0.15	0.33		4.14	
	70.94	0.10	0.22		3.74	
	70.83	0.05	0.11		3.11	
	70.68			1.04		
	70.65				1.16	
	70.67					2.64
X=130'	72.67	0.90	1.97	6.08	7.05	6.53
D=2.184'	72.24	0.70	1.53	6.37	6.59	6.57
	71.80	0.50	1.09	6.16	5.77	6.19
	71.58	0.40	0.87	5.60	5.33	5.77
	71.36	0.30	0.66	5.31	4.94	5.48
	71.14	0.20	0.44	4.72	4.72	5.13
	71.04	0.15	0.33	4.49	4.57	4.52
	70.93	0.10	0.22	3.95	4.11	4.14
	70.82	0.05	0.11	3.51	3.47	3.55
	70.70			2.20		
	70.73				1.79	
	70.68					2.48
X=140'	72.72	0.90	2.02		6.47	
D=2.244'	72.50	0.80	1.80	5.95		6.22
	72.28	0.70	1.57		6.17	
	71.83	0.50	1.12		5.63	
	71.60	0.40	0.90		5.28	
	71.38	0.30	0.67		4.86	
	71.15	0.20	0.45	4.57	4.40	4.80
	71.04	0.15	0.34		4.08	
	70.93	0.10	0.22		3.74	
	70.82	0.05	0.11		3.20	
	70.69			2.43		
	70.70				1.04	
	70.70					0.73

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 64 — Q=100 cfs — S=0.00409 — Temp 65 F — Rock size 1 in. — Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	72.794	0.90	2.08	5.91	6.71	6.79
D=2.306'	72.333	0.70	1.61	6.17	6.04	6.75
	71.872	0.50	1.15	6.04	5.67	6.43
	71.641	0.40	0.92	5.63	5.18	5.95
	71.411	0.30	0.69	5.13	4.80	5.43
	71.180	0.20	0.46	4.52	4.46	4.91
	71.065	0.15	0.35	4.27	4.08	4.52
	70.950	0.10	0.23	3.81	3.66	4.14
	70.834	0.05	0.12	3.11	2.93	3.51
	70.632			1.04		
	70.648				1.04	
	70.695					2.20
X=130'	72.77	0.90	2.06	5.67	6.22	6.34
D=2.292'	72.31	0.70	1.60	5.95	6.04	6.61
	71.86	0.50	1.15	5.91	5.33	6.26
	71.63	0.40	0.92	5.63	5.02	5.99
	71.34	0.30	0.63	5.02	4.80	5.26
	71.17	0.20	0.46	4.63	4.33	4.86
	71.05	0.15	0.34	4.40	3.88	4.33
	70.94	0.10	0.23	4.14	3.66	3.98
	70.82	0.05	0.11	3.36	3.02	3.28
	70.72			2.20		
	70.72				2.20	
	70.71					0.00
X=140'	72.77	6.00	2.07	5.67	6.55	6.47
D=2.297'	72.31	0.70	1.61	5.95	5.97	6.24
	71.86	0.50	1.15	5.60	5.60	6.04
	71.63	0.40	0.92	5.51	5.15	5.72
	71.40	0.30	0.69	5.15	4.57	5.46
	71.17	0.20	0.46	4.75	4.39	4.80
	71.05	0.15	0.34	4.46	3.81	4.60
	70.94	0.10	0.23	4.05	3.55	3.98
	70.82	0.05	0.11	3.51	3.02	3.39
	70.74			2.07		
	70.74				2.14	
	70.64					2.07

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 65	S=0.00998	Rock size 2 in.
Q=50 cfs	Temp 68 F	Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.910	0.90	1.16		6.13	
D=1.292'	71.782	0.80	1.03	5.95		6.47
	71.652	0.70	0.91		5.43	
	71.394	0.50	0.65		4.80	
	71.265	0.40	0.52		4.63	
	71.136	0.30	0.39		4.33	
	71.006	0.20	0.26	3.88	4.01	4.14
	70.942	0.15	0.19		3.36	
	70.877	0.10	0.13		3.11	
	70.812	0.05			2.93	
				1.94	2.32	
	70.747				2.93	
X=130'	71.81	0.90	1.05		6.65	
D=1.170'	71.70	0.80	0.94	6.91		6.91
	71.58	0.70	0.82		6.26	
	71.35	0.50	0.58		5.67	
	71.23	0.40	0.47		5.53	
	71.11	0.30	0.35		5.13	
	70.99	0.20	0.23	4.80	4.46	4.33
	70.94	0.15	0.18		4.14	
	70.88	0.10	0.12		3.66	
	70.82	0.05	0.06		3.44	
	70.80			3.02		
	70.76				2.20	
	70.81					2.32
X=140'	71.91	0.90	1.15		6.43	
D=1.275'	71.78	0.80	1.03	6.43		6.34
	71.66	0.70	0.90		5.81	
	71.40	0.50	0.64		5.08	
	71.27	0.40	0.52		4.63	
	71.15	0.30	0.39		4.33	
	71.02	0.20	0.26	4.01	4.08	3.95
	70.95	0.15	0.20		3.28	
	70.89	0.10	0.13		2.93	
	70.83	0.05	0.07		2.54	
	70.77			1.64		
	70.76				2.07	
	70.77					1.47

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 66	S=0.01378	Rock size 2 in.
Q=50 cfs	Temp 75 F	Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.56	0.90	0.91		7.43	
D=1.012'	71.46	0.80	0.81	7.18		7.10
	71.36	0.70	0.71		6.95	
	71.15	0.50	0.51		6.17	
	71.05	0.40	0.41		5.67	
	70.95	0.30	0.30		5.28	
	70.85	0.20	0.20	4.08	4.86	4.63
	70.80	0.15	0.15		4.46	
	70.75	0.10	0.10		4.01	
	70.70	0.05	0.05		3.66	
	70.63			2.20		
	70.55				2.07	
	70.59					2.74
X=130'	71.56	0.90	0.90		7.49	
D=1.00'	71.46	0.80	0.80	7.42		7.49
	71.36	0.70	0.70		6.95	
	71.16	0.50	0.50		6.34	
	71.06	0.40	0.40		6.00	
	70.96	0.30	0.30		5.79	
	70.86	0.20	0.20	5.05	5.23	5.36
	70.81	0.15	0.15		5.00	
	70.76	0.10	0.10		4.63	
	70.71	0.05	0.05		4.08	
	70.65			2.59		
	70.61				2.93	
	70.66					2.48
X=140'	71.59	0.90	0.94		7.22	
D=1.046'	71.49	0.80	0.84	6.80		7.29
	71.38	0.70	0.73		6.51	
	71.17	0.50	0.52		6.09	
	71.07	0.40	0.42		5.48	
	70.96	0.30	0.31		5.18	
	70.86	0.20	0.21	4.57	4.21	4.14
	70.81	0.15	0.16		3.59	
	70.76	0.10	0.10		3.02	
	70.70	0.05	0.05		2.64	
	70.58			1.94		
	70.56				1.47	
	70.58					2.07

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 67	S=0.01519	Rock size 2 in.
Q=50 cfs	Temp 72 F	Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z -(ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	71.53	0.90	0.88		7.82	
D=0.980'	71.43	0.80	0.78	8.22		7.68
	71.33	0.70	0.69		7.36	
	71.14	0.50	0.49		6.67	
	71.04	0.40	0.39		6.34	
	70.94	0.30	0.29		5.86	
	70.84	0.20	0.20	4.57	5.38	5.58
	70.80	0.15	0.15		4.63	
	70.75	0.10	0.10		3.74	
	70.70	0.05	0.05		2.20	
	70.60			2.07		
	70.60				1.04	
	70.50					0.73
X=130'	71.56	0.90	0.90		7.40	
D=1.00'	71.46	0.80	0.80	7.96		7.96
	71.36	0.70	0.70		7.40	
	71.16	0.50	0.50		6.63	
	71.06	0.40	0.40		6.43	
	70.96	0.30	0.30		5.86	
	70.86	0.20	0.20	5.67	5.13	5.13
	70.81	0.15	0.15		4.80	
	70.76	0.10	0.10		4.33	
	70.71	0.05	0.05		3.51	
	70.64			2.20		
	70.62				2.20	
	70.60					1.27
X=140'	71.54	0.90	0.89		7.86	
D=0.982'	71.44	0.80	0.79	7.61		7.75
	71.34	0.70	0.69		7.10	
	71.14	0.50	0.49		6.55	
	71.04	0.40	0.39		6.13	
	70.95	0.30	0.29		5.58	
	70.85	0.20	0.20	5.08	5.18	4.91
	70.80	0.15	0.15		4.69	
	70.75	0.10	0.10		4.21	
	70.70	0.05	0.05		3.36	
	70.61			2.54		
	70.60				1.79	
	70.61					2.20

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 68		S=0.01796		Rock size 2 in.
Q=50 cfs		Temp 72 F		Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.52	0.90	0.87		8.57	
D=0.963'	71.42	0.80	0.77	8.04		8.90
	71.32	0.70	0.67		7.96	
	71.13	0.50	0.48		7.40	
	71.00	0.40	0.36		7.14	
	70.94	0.30	0.29		6.22	
	70.84	0.20	0.19	5.77	6.02	5.28
	70.79	0.15	0.14		5.88	
	70.74	0.10	0.10		5.18	
	70.70	0.05	0.05		4.80	
	70.59			2.07		
	70.67				4.63	
	70.51					0.00
X=130'	71.50	0.90	0.84		8.07	
D=0.930'	71.40	0.80	0.74	8.13		8.20
	71.31	0.70	0.65		7.70	
	71.12	0.50	0.47		7.16	
	71.03	0.40	0.37		6.87	
	70.94	0.30	0.28		6.45	
	70.84	0.20	0.19	5.63	5.84	5.91
	70.80	0.15	0.14		5.38	
	70.75	0.10	0.09		5.02	
	70.71	0.05	0.05		4.24	
	70.54			2.54		
	70.64				2.88	
	70.58					3.02
X=140'	71.47	0.90	0.82		8.19	
D=0.914'	71.38	0.80	0.73	7.92		8.02
	71.29	0.70	0.64		7.94	
	71.11	0.50	0.46		7.22	
	71.01	0.40	0.37		7.03	
	70.92	0.30	0.28		6.59	
	70.83	0.20	0.18	5.28	6.24	5.31
	70.76	0.15	0.11		5.86	
	70.74	0.10	0.09		5.79	
	70.69	0.05	0.05		4.57	
	70.71			2.84		
	70.62				0.73	
	70.64					1.27

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 69	S=0.01888	Rock size 2 in.
Q=50 cfs	Tepm 68 F	Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.50	0.90	0.85		8.50	
D=0.948'	71.40	0.80	0.76	8.40		8.76
	71.31	0.70	0.66		8.00	
	71.12	0.50	0.47		7.22	
	71.03	0.40	0.38		6.70	
	70.93	0.30	0.28		6.77	
	70.84	0.20	0.19	5.31	6.26	5.79
	70.79	0.15	0.14		5.93	
	70.74	0.10	0.09		5.74	
	70.69	0.05	0.05		4.75	
	70.27			1.04		
	70.52				3.00	
	70.57					2.07

CORPS OF ENGINEERS RIPRAP PROJECT

	Run # 70	S=0.01110	Rock size 2 in.
	Q=75 cfs	Temp 69 F	Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.92	0.90	1.27		8.54	
D=1.410'	71.78	0.80	1.13	8.35		8.26
	71.64	0.70	0.99		8.12	
	71.35	0.50	0.70		7.23	
	71.21	0.40	0.56		6.83	
	71.07	0.30	0.42		6.45	
	70.93	0.20	0.28	6.47	5.84	6.26
	70.85	0.15	0.20		5.31	
	70.79	0.10	0.14		5.08	
	70.72	0.05	0.07		4.57	
	70.72			4.30		
	70.57				3.36	
	70.57					2.20

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 71	S=0.00781	Rock size 2 in.		
Q=75 cfs	Temp 70 F	Thickness 4 in.		

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.00	0.90	1.35	7.00	7.60	7.06
D=1.498'	71.70	0.70	1.05	7.08	6.95	7.27
	71.40	0.50	0.75	6.85	6.53	6.75
	71.25	0.40	0.60	6.34	6.13	6.70
	71.10	0.30	0.45	5.84	5.53	5.93
	70.95	0.20	0.30	5.36	5.05	5.10
	70.87	0.15	0.23	5.05	4.43	4.52
	70.80	0.10	0.15	4.46	3.66	3.59
	70.72	0.05	0.08	4.91	3.06	2.84
	70.63			2.84		
	70.65				2.69	
	70.58					1.87
X=130'	71.99	0.90	1.33	7.18	7.75	7.25
D=1.474'	71.69	0.70	1.03	7.29	7.47	7.22
	71.40	0.50	0.74	6.79	6.75	6.91
	71.25	0.40	0.59	6.51	6.17	6.63
	71.10	0.30	0.44	5.95	5.81	6.26
	70.95	0.20	0.30	5.43	5.33	5.67
	70.88	0.15	0.22	4.69	5.08	5.08
	70.81	0.10	0.15	4.14	7.75	4.63
	70.73	0.05	0.07	3.74	4.14	3.95
	70.58			3.11		
	70.60				4.52	
	70.51					3.19
X=140'	71.98	0.90		7.27	7.66	7.00
D=1.476'	71.68	0.70		7.03	7.05	7.23
	71.39	0.50		6.85	6.70	6.89
	71.24	0.40		6.63	6.09	6.55
	71.09	0.30		6.13	5.60	6.02
	70.95	0.20		5.58	5.38	5.60
	70.87	0.15		5.33	5.18	5.10
	70.80	0.10		4.55	4.49	4.49
	70.72	0.05		4.08	4.21	4.05
	70.65			4.05		
	70.60				4.18	
	70.61					2.00

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 72 S=0.00937 Rock size 2 in.
Q=75 cfs Temp 70 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.94	0.90	1.29		8.14	
D=1.432'	71.79	0.80	1.15	7.65		7.63
	71.65	0.70	1.00		7.49	
	71.36	0.50	0.72		6.93	
	71.22	0.40	0.57		6.43	
	71.08	0.30	0.43		5.97	
	70.93	0.20	0.29	5.72	5.65	5.41
	70.86	0.15	0.22		5.05	
	70.79	0.10	0.14		4.57	
	70.72	0.05	0.07		3.36	
	70.65			2.74		
	70.65				2.84	
	70.66					0.90
X=130'	71.95	0.90	1.29	7.68	8.19	7.54
D=1.431'	71.66	0.70	1.00	7.86	7.86	7.79
	71.37	0.50	0.71	7.47	7.25	7.44
	71.23	0.40	0.57	7.22	6.87	7.06
	71.08	0.30	0.42	6.75	6.34	6.67
	70.94	0.20	0.28	6.26	5.67	6.04
	70.87	0.15	0.21	5.77	5.28	5.53
	70.80	0.10	0.14	5.29	4.63	4.91
	70.73	0.05	0.07	4.40	2.84	2.54
	70.56			1.47		
	70.61				0.73	
	70.63					0.00
X=140'	71.92	0.90	1.27		7.92	
D=1.405'	71.78	0.80	1.13	7.66		7.58
	71.63	0.70	0.98		7.36	
	71.35	0.50	0.70		6.73	
	71.21	0.40	0.56		6.22	
	71.07	0.30	0.42		5.95	
	70.93	0.20	0.28	4.46	4.83	5.63
	70.86	0.15	0.21		4.66	
	70.79	0.10	0.14		4.05	
	70.72	0.05	0.07		3.02	
	70.56			1.55		
	70.63				1.27	
	70.56					2.14

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 73	S=0.00731	Rock size 2 in.
Q=100 cfs	Temp 72 F	Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.41	0.90	1.76		8.26	
D=1.960'	72.22	0.80	1.57	7.22		7.00
	72.02	0.70	1.37		7.61	
	71.63	0.50	0.98		7.14	
	71.43	0.40	0.78		6.51	
	71.24	0.30	0.59		6.00	
	71.04	0.20	0.39	5.67	5.72	5.81
	70.94	0.15	0.29		5.28	
	70.84	0.10	0.20		4.75	
	70.75	0.05	0.10		3.02	
	70.60			2.47		
	70.58				2.64	
	70.65					3.73
X=130'	72.39	0.90	1.73	7.05	8.12	6.81
D=1.923'	72.00	0.70	1.35	7.12	7.79	6.99
	71.62	0.50	0.96	7.00	6.81	6.93
	71.43	0.40	0.77	6.51	6.13	6.55
	71.24	0.30	0.58	6.13	5.84	5.95
	71.04	0.20	0.39	5.33	5.70	5.53
	70.95	0.15	0.29	4.94	5.02	5.13
	70.85	0.10	0.19	5.18	4.69	5.02
	70.75	0.05	0.10	4.66	4.01	4.57
	70.61			3.74		
	70.60				2.37	
	70.75					4.69
X=140'	72.43	0.90	1.78		8.02	
D=1.978'	72.23	0.80	1.58	6.80		6.95
	72.04	0.70	1.38		7.65	
	71.64	0.50	0.99		6.87	
	71.44	0.40	0.79		6.43	
	71.24	0.30	0.59		5.86	
	71.05	0.20	0.40	5.30	5.38	5.43
	70.95	0.15	0.30		5.00	
	70.85	0.10	0.20		4.27	
	70.75	0.05	0.10		3.74	
	70.60			3.44		
	70.62				2.07	
	70.59					3.11

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 74	S=0.00840	Rock size 2 in.
Q=100 cfs	Temp 71 F	Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	72.39	0.90	1.74	7.08	8.40	7.54
D=1.932'	72.00	0.70	1.35	7.74	8.02	7.86
	71.61	0.50	0.97	7.33	7.03	7.45
	71.42	0.40	0.77	7.06	6.65	7.16
	71.23	0.30	0.58	6.61	5.88	6.51
	71.03	0.20	0.39	6.26	5.33	6.02
	70.94	0.15	0.29	5.65	5.00	5.18
	70.84	0.10	0.19	5.23	4.78	4.66
	70.74	0.05	0.10	3.73	4.40	4.27
	70.64			2.59		
	70.56				2.54	
	70.63					3.28
X=130'	72.30	0.90	1.65	7.22	8.59	7.45
D=1.831'	71.94	0.70	1.28	7.54	8.07	7.77
	71.57	0.50	0.92	7.14	7.23	7.40
	71.39	0.40	0.73	6.91	6.95	6.73
	71.21	0.30	0.55	6.45	6.67	6.55
	71.02	0.20	0.37	5.91	5.91	6.06
	70.93	0.15	0.27	5.36	5.61	5.51
	70.84	0.10	0.18	5.08	5.15	5.02
	70.75	0.05	0.09	4.46	3.98	4.63
	70.61			3.63		
	70.60				3.32	
	70.58					2.93
X=140'	72.37	0.90	1.72	7.54	8.48	7.10
D=1.909'	71.98	0.70	1.34	7.68	7.75	7.74
	71.60	0.50	0.95	7.22	7.14	7.20
	71.41	0.40	0.76	6.71	6.93	6.85
	71.22	0.30	0.57	6.32	6.24	6.26
	71.03	0.20	0.38	5.72	5.41	5.79
	70.93	0.15	0.29	5.41	5.08	5.67
	70.84	0.10	0.19	4.69	4.46	4.91
	70.74	0.05	0.09	4.05	3.84	4.08
	70.58			2.07		
	70.63				2.69	
	70.60					1.79

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 75	S=0.01066	Rock size 2 in.
Q=100 cfs	Temp 70 F	Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.27	0.90	1.62		8.91	
D=1.804'	72.09	0.80	1.44	8.02		8.09
	71.91	0.70	1.26		8.40	
	71.55	0.50	0.90		7.70	
	71.37	0.40	0.72		7.16	
	71.19	0.30	0.54		6.65	
	71.01	0.20	0.36	6.04	5.86	5.88
	70.92	0.15	0.27		5.72	
	70.83	0.10	0.18		5.53	
	70.74	0.05	0.09		4.86	
	70.59			1.47		
	70.56				0.73	
	70.65					3.23
X=130'	72.28	0.90	1.62		8.76	
D=1.800'	72.10	0.80	1.44	8.02		7.68
	71.92	0.70	1.26		8.16	
	71.56	0.50	0.90		7.40	
	71.38	0.40	0.72		7.25	
	71.20	0.30	0.54		6.51	
	71.02	0.20	0.36	5.86	6.13	5.81
	70.93	0.15	0.27		5.58	
	70.84	0.10	0.18		5.43	
	70.75	0.05	0.09		4.80	
	70.63			1.27		
	70.58				1.64	
	70.56					1.27
X=140'	72.28	0.90	1.63		8.73	
D=1.808'	72.10	0.80	1.45	7.92		7.51
	71.92	0.70	1.27		8.12	
	71.60	0.30	0.95		7.61	
	71.42	0.40	0.77		7.22	
	71.24	0.30	0.59		6.55	
	71.06	0.20	0.41	6.26	6.26	5.67
	70.97	0.15	0.32		5.53	
	70.88	0.10	0.23		4.75	
	70.79	0.05	0.14		3.81	
	70.71			4.21		
	70.66				1.64	
	70.56					0.00

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 76	S=0.01193	Rock size 2 in.
Q=25 cfs	Temp 67 F	Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	71.25	0.90	0.60	5.23	5.81	5.58
D=0.666'	71.11	0.70	0.47	5.02	5.43	5.28
	70.98	0.50	0.33	4.46	4.97	4.69
	70.91	0.40	0.27	4.14	4.69	4.40
	70.85	0.30	0.20	3.88	4.40	4.08
	70.78	0.20	0.13	3.51	3.81	3.59
	70.75	0.15	0.10	3.28	2.93	3.44
	70.72	0.10	0.07	3.02	1.64	3.02
	70.68	0.05	0.03	1.64	0.73	2.54
	70.66			0.00		
	70.63				0.00	
	70.59					1.66
X=130'	71.26	0.90	0.60	5.23	5.51	5.70
D=0.668'	71.12	0.70	0.47	5.15	5.38	5.33
	70.99	0.50	0.33	4.83	4.97	4.89
	70.92	0.40	0.27	4.52	4.49	4.69
	70.86	0.30	0.20	3.81	4.33	4.40
	70.79	0.20	0.13	3.59	3.91	3.66
	70.76	0.15	0.10	3.44	3.59	3.66
	70.72	0.10	0.07	3.02	3.44	3.32
	70.69	0.05	0.03	2.64	3.28	2.88
	70.62			1.16		
	70.62				2.59	
	70.60					1.72
X=140'	71.29	0.90	0.64	5.28	5.75	5.28
D=0.708'	71.15	0.70	0.50	5.07	5.23	5.07
	71.00	0.50	0.35	4.52	4.91	4.57
	70.93	0.40	0.28	4.21	4.40	4.33
	70.86	0.30	0.21	3.81	4.21	3.88
	70.79	0.20	0.14	3.44	3.81	3.66
	70.76	0.15	0.11	3.19	3.66	3.51
	70.72	0.10	0.07	2.93	3.66	3.28
	70.69	0.05	0.03	2.84	3.19	3.02
	70.66			2.74		
	70.64				2.84	
	70.64					2.43

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 77	S=0.01858	Rock size 2 in.
Q=25 cfs	Temp 67 F	Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.20	0.90	0.55		6.26	
D=0.610'	71.14	0.80	0.49	5.95		5.91
	71.08	0.70	0.43		5.95	
	70.95	0.50	0.31		5.62	
	70.89	0.40	0.24		5.23	
	70.83	0.30	0.18		4.97	
	70.77	0.20	0.12	4.08	4.75	4.27
	70.74	0.15	0.09		4.57	
	70.71	0.10	0.06		4.33	
	70.68	0.05	0.03		3.74	
	70.63			2.43		
	70.62				3.51	
	70.68					3.88
X=130'	71.18	0.90	0.52		6.53	
D=0.577'	71.12	0.80	0.46	6.51		6.47
	71.06	0.70	0.40		6.17	
	70.95	0.50	0.29		5.81	
	70.89	0.40	0.23		5.51	
	70.83	0.30	0.17		5.08	
	70.77	0.20	0.11	4.27	4.78	4.40
	70.75	0.15	0.09		4.49	
	70.72	0.10	0.06		4.14	
	70.69	0.05	0.03		3.91	
	70.62			2.14		
	70.62				4.01	
	70.62					2.07
X=140'	71.20	0.90	0.55		6.59	
D=0.608'	71.14	0.80	0.49	6.00		6.39
	71.08	0.70	0.43		6.22	
	70.95	0.50	0.30		5.48	
	70.89	0.40	0.24		5.13	
	70.83	0.30	0.18		4.75	
	70.77	0.20	0.12	4.08	4.27	3.95
	70.74	0.15	0.09		4.01	
	70.71	0.10	0.06		3.36	
	70.68	0.05	0.03		3.02	
	70.66			3.66		
	70.65				2.93	
	70.63					2.32

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 78	S=0.01579	Rock size 2 in.
Q=50 cfs	Temp 68 F	Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.59	0.90	0.95	7.86	7.23	8.46
D=1.050'	71.38	0.70	0.73	7.51	6.53	8.27
	71.17	0.50	0.53	6.53	5.72	7.47
	71.07	0.40	0.42	6.24	5.23	7.03
	70.96	0.30	0.31	5.56	4.30	6.63
	70.86	0.20	0.21	5.00	4.14	6.11
	70.81	0.15	0.16	4.66	3.63	5.97
	70.75	0.10	0.11	4.46	3.19	5.31
	70.70	0.05	0.05	3.84	3.51	5.13
	70.60			2.74		
	70.60				3.15	
	70.52					3.15
X=130'	71.52	0.90	0.86	7.99	8.12	7.96
D=0.961'	71.33	0.70	0.67	7.43	7.43	7.68
	71.14	0.50	0.48	6.75	6.83	7.03
	71.04	0.40	0.38	6.47	6.71	6.63
	70.95	0.30	0.29	5.95	6.13	6.17
	70.85	0.20	0.19	5.43	5.77	5.67
	70.80	0.15	0.14	4.97	5.28	5.08
	70.75	0.10	0.10	4.69	5.02	4.97
	70.71	0.05	0.05	3.95	4.21	4.46
	70.60			1.27		
	70.57				3.11	
	70.61					2.64
X=140'	71.60	0.90	0.95	7.87	7.67	7.58
D=1.056'	71.39	0.70	0.74	7.43	7.20	7.42
	71.18	0.50	0.53	6.49	6.63	6.57
	71.07	0.40	0.42	6.22	6.11	6.02
	70.97	0.30	0.32	5.67	5.53	5.33
	70.86	0.20	0.21	4.57	4.78	4.75
	70.81	0.15	0.16	3.77	4.49	4.30
	70.76	0.10	0.11	3.36	3.74	3.95
	70.70	0.05	0.05		3.28	
	70.72			3.11		
	70.70				3.44	
	70.73					0.00

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 79
Q=25 cfs

S=0.01180
Temp. 68 F

Rock size 2 in.
Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	71.46	0.90	0.64	5.53	5.77	5.58
D=0.714'	71.32	0.70	0.50	5.13	5.28	5.13
	71.18	0.50	0.36	4.69	4.97	4.80
	71.11	0.40	0.29	4.33	4.57	4.52
	71.03	0.30	0.21	3.74	4.27	4.27
	70.96	0.20	0.14	3.44	3.95	3.95
	70.93	0.15	0.11	3.19	3.74	3.66
	70.89	0.10	0.07	2.84	3.59	3.44
	70.86	0.05	0.04	2.64	3.36	3.19
	70.72			1.47		
	70.80				2.64	
	70.77					2.84
X=130'	71.44	0.90	0.63	5.18	5.60	5.67
D=0.702'	71.30	0.70	0.49	4.69	5.48	5.33
	71.16	0.50	0.35	4.21	5.02	4.66
	71.09	0.40	0.28	4.18	4.78	4.49
	71.02	0.30	0.21	3.66	4.30	4.05
	70.95	0.20	0.14	3.47	3.74	3.32
	70.91	0.15	0.11	2.88	3.70	3.06
	70.88	0.10	0.07	2.93	3.59	2.93
	70.84	0.05	0.03	2.84	3.28	2.59
	70.72			2.00		
	70.71				1.37	
	70.74					0.90
X=140'	71.44	0.90	0.64	5.33	5.63	5.63
D=0.713'	71.30	0.70	0.50	5.13	5.46	5.18
	71.16	0.50	0.36	4.63	5.07	4.75
	71.08	0.40	0.28	4.27	4.52	4.33
	71.01	0.30	0.21	3.81	4.33	3.74
	70.94	0.20	0.14	3.44	3.66	3.02
	70.91	0.15	0.11	3.02	3.36	2.74
	70.87	0.10	0.07	2.74	3.19	2.43
	70.84	0.05	0.04	2.32	2.74	1.94
	70.79			1.94		
	70.75				1.94	
	70.81					1.79

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 80	S=0.01870	Rock zise 2 in.
Q=25 cfs	Temp. 69 F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	71.37	0.90	0.55	6.30	6.55	6.17
D=0.612'	71.25	0.70	0.43	6.00	6.22	5.86
	71.13	0.50	0.31	5.53	5.53	5.38
	71.07	0.40	0.25	5.33	5.13	5.18
	71.00	0.30	0.18	4.69	4.97	4.80
	71.94	0.20	1.12	4.00	4.33	4.46
	70.91	0.15	0.09	3.81	4.08	4.14
	70.88	0.10	0.06	3.36	3.81	3.88
	70.85	0.05	0.03	3.10	3.74	3.88
	70.73			2.07		
	70.85				3.81	
	70.75					0.73
X=130'	71.36	0.90	0.55	6.09	6.55	6.34
D=0.614'	71.24	0.70	0.43	5.67	6.39	6.00
	71.11	0.50	0.31	5.23	5.77	5.67
	71.05	0.40	0.25	4.75	5.43	5.28
	70.99	0.30	0.18	4.33	4.91	5.08
	70.93	0.20	0.12	4.08	4.52	4.63
	70.90	0.15	0.09	3.88	4.14	1.64
	70.87	0.10	0.06	3.81	3.81	0.00
	70.84	0.05	0.03	3.74	3.74	0.00
	70.84			0.00		
	70.72				2.54	
	70.77					
X=140'	71.33	0.90	0.53	6.26	6.63	6.67
D=0.594'	71.22	0.70	0.42	5.77	6.34	6.13
	71.10	0.50	0.30	5.38	5.63	5.72
	71.04	0.40	0.24	5.02	5.18	5.43
	70.98	0.30	0.18	4.52	4.69	4.63
	70.92	0.20	0.12	3.81	4.21	3.51
	70.89	0.15	0.09	3.51	3.81	2.93
	70.86	0.10	0.06	3.02	3.51	2.32
	70.83	0.05	0.03	2.74	3.11	1.64
	70.80			2.07		
	70.78				2.54	
	70.78					1.04

CORP OF ENGINEERS RIPRAP PROJECT

RUN # 81	S=0.01205	Rock size 2 in.
Q=50 cfs	Twmp. 70 F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	71.79	0.90	0.97		7.31	
D=1.078'	71.68	0.80	0.86	7.42		7.05
	71.58	0.70	0.76		6.81	
	71.36	0.50	0.54		6.41	
	71.25	0.40	0.43		6.00	
	71.14	0.30	0.32		5.43	
	71.04	0.20	0.22	5.21	4.89	5.26
	70.98	0.15	0.16		4.46	
	70.93	0.10	0.11		4.30	
	70.87	0.05	0.05		4.00	
	70.72			2.07		
	70.72				3.47	
	70.78					3.44
X=130'	71.76	0.90	0.95		7.03	
D=1.060'	71.85	0.80	1.05	7.12		6.97
	71.55	0.70	0.74		6.73	
	71.34	0.50	0.53		6.39	
	71.23	0.40	0.42		6.04	
	71.12	0.30	0.32		5.53	
	71.02	0.20	0.21	4.89	4.94	5.23
	70.97	0.15	0.16		4.52	
	70.91	0.10	0.11		4.36	
	70.86	0.05	0.05		3.95	
	70.78			2.97		
	70.69				2.84	
	70.81					1.87
X=140'	71.76	0.90	0.96		7.36	
D=1.065'	71.65	0.80	0.85	7.20		7.16
	71.55	0.70	0.75		6.95	
	71.33	0.50	0.53		6.43	
	71.23	0.40	0.43		6.11	
	71.12	0.30	0.32		5.48	
	71.01	0.20	0.21	4.63	4.97	5.18
	70.96	0.15	0.16		4.60	
	70.91	0.10	0.11		4.36	
	70.85	0.05	0.05		3.66	
	70.76			0.90		
	70.77				1.94	
	70.73					1.87

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 82 S=0.01544 Rock size 2 in.
Q=50 cfs Temp. 67 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	71.69	0.90	0.87	7.92	7.61	7.99
D=0.968'	71.50	0.70	0.68	7.82	7.33	7.54
	71.30	0.50	0.48	7.36	6.83	6.95
	71.21	0.40	0.39	6.71	6.34	6.47
	71.11	0.30	0.29	6.34	5.95	6.30
	71.01	0.20	0.19	5.48	5.48	5.67
	70.97	0.15	0.15	5.18	5.18	5.28
	70.92	0.10	0.10	4.86	4.86	4.97
	70.87	0.05	0.05	4.01	4.52	4.52
	70.75			1.27		
	70.82				4.33	
	70.78					3.19
X=130'	71.68	0.90	0.98	7.87	7.68	7.89
D=0.976'	71.49	0.70	0.78	7.38	7.36	7.61
	71.29	0.50	0.59	6.75	6.81	7.05
	71.20	0.40	0.49	6.37	6.13	6.97
	71.10	0.30	0.39	5.72	5.93	6.17
	71.00	0.20	0.30	5.10	5.53	5.43
	70.95	0.15	0.25	4.63	5.26	5.23
	70.90	0.10	0.20	4.33	4.60	4.69
	70.86	0.05	0.15	3.63	4.52	4.24
	70.79			2.48		
	70.76				3.84	
	70.81					3.47
X=140'	71.66	0.90	0.86	7.89	7.99	7.99
D=0.955'	71.47	0.70	0.67	7.36	7.40	7.61
	71.28	0.50	0.48	7.06	6.87	6.99
	71.18	0.40	0.38	6.63	6.63	6.67
	71.09	0.30	0.29	5.86	6.26	6.30
	70.99	0.20	0.19	5.28	5.58	5.77
	70.94	0.15	0.14	4.86	5.18	5.23
	70.90	0.10	0.10	4.40	4.27	4.33
	70.85	0.05	0.05	3.51	3.44	3.36
	70.80			3.44		
	70.77				1.79	
	70.82					2.54

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 83	S=0.01724	Rock size 2 in.
Q=50 cfs	Temp. 67 F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	71.64	0.90	0.82		8.09	
D=0.913'	71.55	0.80	0.73	8.32		8.19
	71.46	0.70	0.64		7.68	
	71.28	0.50	0.46		7.14	
	71.19	0.40	0.37		6.83	
	71.09	0.30	0.27		6.43	
	71.00	0.20	0.18	6.06	5.48	5.53
	70.96	0.15	0.14		5.08	
	70.91	0.10	0.09		4.75	
	70.87	0.05	0.05		4.08	
	70.74			2.59		
	70.81				4.01	
	70.75					2.84
X=130'	71.66	0.90	0.85		7.96	
D=0.943'	71.56	0.80	0.76	8.11		8.17
	71.47	0.70	0.66		7.65	
	71.28	0.50	0.47		7.03	
	71.18	0.40	0.38		6.63	
	71.09	0.30	0.28		6.08	
	71.00	0.20	0.19	5.74	5.53	5.91
	70.95	0.15	0.14		5.23	
	70.90	0.10	0.09		4.86	
	70.85	0.05	0.05		4.57	
	70.76			2.48		
	70.75				1.04	
	70.79					1.47
X=140'	71.63	0.90	0.83		8.19	
D=0.928'	71.54	0.80	0.74	7.94		8.32
	71.45	0.70	0.65		7.65	
	71.26	0.50	0.46		7.10	
	71.17	0.40	0.37		6.67	
	71.08	0.30	0.28		6.13	
	70.99	0.20	0.19	5.31	5.38	5.81
	70.94	0.15	0.14		4.63	
	70.89	0.10	0.09		4.27	
	70.85	0.05	0.05		3.51	
	70.84			1.72		
	70.76				1.67	
	70.83					4.30

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 84	S=0.01879	Rock size 2 in.
Q=50 cfs	Temp. 68F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	71.64	0.90	0.82		8.48	
D=0.916'	71.55	0.80	0.73	8.64		8.42
	71.46	0.70	0.64		7.89	
	71.28	0.50	0.46		7.47	
	71.19	0.40	0.37		6.69	
	71.10	0.30	0.28		6.00	
	71.00	0.20	0.18	5.58	5.51	6.13
	70.96	0.15	0.14		5.18	
	70.91	0.10	0.09		4.55	
	70.87	0.05	0.05		3.40	
	70.76			2.32		
	70.85				3.40	
	70.72					2.07
X=130'	71.70	0.90	0.90		8.04	
D=0.995'	71.60	0.80	0.80	8.29		8.79
	71.50	0.70	0.70		7.38	
	71.30	0.50	0.50		6.67	
	71.20	0.40	0.40		6.43	
	71.11	0.30	0.30		5.63	
	71.01	0.20	0.20	5.91	5.41	6.34
	70.96	0.15	0.15		4.78	
	70.91	0.10	0.10		4.40	
	70.86	0.05	0.05		3.95	
	70.80			0.00		
	70.73				0.90	
	70.74					1.79
X=140'	71.70	0.90	0.90		8.34	
D=0.998'	71.60	0.80	0.80	8.61		8.45
	71.50	0.70	0.70		8.16	
	71.30	0.50	0.50		7.36	
	71.20	0.40	0.40		7.18	
	71.10	0.30	0.30		6.75	
	71.00	0.20	0.20	5.18	6.13	5.86
	70.95	0.15	0.15		5.81	
	70.90	0.10	0.10		5.48	
	70.85	0.05	0.05		4.80	
	70.80			3.66		
	70.77				4.46	
	70.81					3.11

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 85	S=0.00898	Rock size 2 in.
Q=75 cfs	Temp. 72 F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	72.16	0.90	1.34	7.36	7.99	7.33
D=1.492'	71.86	0.70	1.04	7.47	7.29	7.29
	71.57	0.50	0.75	7.03	6.47	6.99
	71.42	0.40	0.60	6.34	6.00	6.63
	71.27	0.30	0.45	5.86	5.63	6.04
	71.12	0.20	0.30	5.38	5.07	5.63
	71.04	0.15	0.22	5.38	4.75	4.80
	70.97	0.10	0.15	4.80	4.21	4.69
	70.90	0.05	0.08	3.81	3.66	4.14
	70.70			1.27		
	70.74				1.94	
	70.77					3.19
X=130'	72.19	0.90	1.38	7.22	7.60	7.14
D=1.537'	71.88	0.70	1.08	7.42	6.65	7.23
	71.58	0.50	0.77	6.95	6.17	6.99
	71.42	0.40	0.62	6.63	5.93	6.45
	71.27	0.30	0.46	6.19	5.31	6.02
	71.11	0.20	0.31	5.79	4.69	5.72
	71.04	0.15	0.23	5.05	4.46	5.21
	70.96	0.10	0.15	4.66	4.01	4.89
	70.88	0.05	0.08	3.36	3.36	4.24
	70.87			2.98		
	70.87				2.54	
	70.70					2.37
X=140'	72.17	0.90	1.38	7.29	7.42	6.97
D=1.528'	71.87	0.70	1.07	7.14	7.23	7.12
	71.56	0.50	0.76	6.73	6.34	6.53
	71.41	0.40	0.61	6.65	5.93	6.45
	71.26	0.30	0.46	6.02	5.46	5.77
	71.11	0.20	0.31	5.41	4.60	4.72
	71.03	0.15	0.23	5.10	4.21	4.30
	70.95	0.10	0.15	4.46	3.88	3.59
	70.88	0.05	0.08	3.77	1.79	2.20
	70.73			0.00		
	70.75				1.27	
	70.81					1.64

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 86	S=0.01095	Rock size 2 in.
Q=75 cfs	Temp. 72 F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	72.09	0.90	1.27		8.24	
D=1.406'	71.95	0.80	1.13	7.91		7.86
	71.80	0.70	0.98		7.45	
	71.52	0.50	0.70		7.10	
	71.38	0.40	0.56		6.55	
	71.24	0.30	0.42		6.22	
	71.10	0.20	0.28	5.33	5.48	5.79
	71.03	0.15	0.21		4.91	
	70.96	0.10	0.14		4.55	
	70.89	0.05	0.07		3.81	
	70.72			0.00		
	70.67				1.72	
	70.73					1.27
X=130'	72.08	0.90	1.28		7.70	
D=1.418'	71.94	0.80	1.13	7.60		7.65
	71.80	0.70	0.99		7.56	
	71.52	0.50	0.71		6.75	
	71.37	0.40	0.57		6.28	
	71.23	0.30	0.42		5.86	
	71.09	0.20	0.28	5.77	5.18	5.91
	71.02	0.15	0.21		5.02	
	70.95	0.10	0.14		4.72	
	70.88	0.05	0.07		4.01	
	70.83			2.32		
	70.75				1.16	
	70.79					3.06
X=140'	72.08	0.90	1.28		8.19	
D=1.419'	71.93	0.80	1.13	7.65		7.68
	71.79	0.70	0.99		7.80	
	71.51	0.50	0.71		7.06	
	71.37	0.40	0.57		6.77	
	71.23	0.30	0.43		6.02	
	71.08	0.20	0.28	5.86	5.36	6.02
	71.01	0.15	0.21		5.13	
	70.94	0.10	0.14		4.49	
	70.87	0.05	0.07		3.95	
	70.73			2.59		
	70.80				3.11	
	70.79					0.00

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 87 Q=75 cfs | S=0.01206 Temp. 73 F | Rock size 2 in. Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67
X=120'	72.09	0.90	1.27		8.57	
D=1.410'	71.95	0.80	1.13	8.35		8.17
	71.81	0.70	0.99		7.61	
	71.53	0.50	0.71		6.79	
	71.38	0.40	0.56		6.39	
	71.24	0.30	0.42		6.00	
	71.10	0.20	0.28	5.77	5.33	6.06
	71.03	0.15	0.21		5.18	
	70.96	0.10	0.14		4.52	
	70.89	0.05	0.07		3.74	
	70.79			3.98		
	70.79				3.11	
	70.71					2.48
X=130'	72.11	0.90	1.31		8.38	
D=1.445'	71.96	0.80	1.16	7.99		8.01
	71.82	0.70	1.02		7.89	
	71.53	0.50	0.73		6.95	
	71.38	0.40	0.58		6.71	
	71.24	0.30	0.44		6.26	
	71.10	0.20	0.30	5.91	5.58	6.11
	71.02	0.15	0.22		5.08	
	70.95	0.10	0.15		4.52	
	70.88	0.05	0.08		4.08	
	70.70			3.66		
	10.82				2.54	
	70.74					3.11
X=140'	72.07	0.90	1.27		8.67	
D=1.415'	71.93	0.80	1.13	8.12		8.22
	71.79	0.70	0.99		7.89	
	71.51	0.50	0.71		7.29	
	71.37	0.40	0.57		7.03	
	71.22	0.30	0.42		6.39	
	71.08	0.20	0.28	6.28	5.72	5.91
	71.01	0.15	0.21		5.43	
	70.94	0.10	0.14		4.69	
	70.87	0.05	0.07		4.14	
	70.72			0.73		
	70.76				2.20	
	70.84					1.16

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 88	S=0.01359	Rock size 2 in.
Q=75 cfs	Temp. 73 F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	72.06	0.90	1.24		8.70	
D=1.382'	71.93	0.80	1.11	8.45		8.45
	71.79	0.70	0.97		8.19	
	71.51	0.50	0.69		7.68	
	71.37	0.40	0.55		6.95	
	71.24	0.30	0.42		6.51	
	71.10	0.20	0.28	5.91	5.86	6.00
	71.03	0.15	0.21		5.33	
	70.96	0.10	0.14		4.80	
	70.89	0.05	0.07		4.46	
	70.75			1.04		
	70.77				2.64	
	70.75					0.00
X=130'	72.05	0.90	1.24		8.82	
D=1.377'	71.91	0.80	1.10	8.54		8.19
	71.77	0.70	0.96		7.96	
	71.50	0.50	0.69		7.58	
	71.36	0.40	0.55		7.29	
	71.22	0.30	0.41		6.55	
	71.08	0.20	0.28	6.26	6.00	
	71.01	0.15	0.21		5.43	6.26
	70.94	0.10	0.14		4.75	
	70.88	0.05	0.07		4.33	
	70.59			0.73		
	70.75				3.28	
	70.73					4.27
X=140'	72.02	0.90	1.22		8.88	
D=1.356'	71.88	0.80	1.08	8.22		8.38
	71.75	0.70	0.95		8.35	
	71.48	0.50	0.68		7.58	
	71.34	0.40	0.54		7.29	
	71.21	0.30	0.41		6.95	
	71.07	0.20	0.27	6.17	6.09	5.23
	71.00	0.15	0.20		5.58	
	70.94	0.10	0.14		5.08	
	70.87	0.05	0.07		4.27	
	70.75			1.64		
	70.76				3.36	
	70.81					2.83

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 89 S=0.01565 Rock size 2 in.
Q=75 cfs Temp. 75 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=130'	72.07	0.90	1.26		9.06	
D=1.399'	71.93	0.80	1.12	8.95		9.03
	71.79	0.70	0.98		8.37	
	71.51	0.50	0.70		7.72	
	71.37	0.40	0.56		7.00	
	71.23	0.30	0.42		6.71	
	71.09	0.20	0.28	6.22	5.48	5.67
	71.02	0.15	0.21		4.91	
	70.95	0.10	0.14		4.55	
	70.88	0.05	0.07		2.64	
	70.75			2.54		
	70.80				1.27	
	70.72					3.02

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 90	S=0.00866	Rock size 2 in.
Q=100 cfs	Temp. 77 F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	72.45	0.90	1.63	8.67	8.75	7.68
D=1.805'	72.08	0.70	1.26	8.53	8.01	7.91
	71.72	0.50	0.90	7.99	7.67	7.36
	71.54	0.40	0.72	7.27	7.05	7.05
	71.36	0.30	0.54	6.73	6.63	6.59
	71.18	0.20	0.36	6.30	6.08	6.02
	71.09	0.15	0.27	6.24		5.41
	71.00	0.10	0.18	5.70	5.18	5.02
	70.91	0.05	0.09	5.05	3.74	4.01
	70.75			2.84		0.00
	70.82				2.74	
	70.77					1.37
X=130'	72.44	0.90	1.63	7.36	8.82	7.68
D=1.816'	72.08	0.70	1.27	7.47	8.22	7.82
	71.71	0.50	0.91	6.99	7.43	7.51
	71.53	0.40	0.73	6.51	7.03	7.06
	71.35	0.30	0.55	5.81	6.55	6.39
	71.17	0.20	0.36	5.48	5.86	5.67
	71.08	0.15	0.27	5.13	5.48	5.18
	70.99	0.10	0.18	4.63	4.86	4.91
	70.90	0.05	0.09	2.93	4.21	3.44
	70.73			0.00		
	70.75				2.64	
	70.72					1.47
X=140'	72.43	0.90	1.62	7.68	8.82	7.60
D=1.803'	72.06	0.70	1.26	7.68	8.27	7.96
	71.70	0.50	0.90	7.23	7.33	7.68
	71.52	0.40	0.72	7.10	6.95	7.14
	71.34	0.30	0.54	6.73	6.61	6.53
	71.16	0.20	0.36	5.60	5.58	5.97
	71.07	0.15	0.27	5.00	5.13	5.26
	70.98	0.10	0.18	4.77	4.91	4.63
	70.89	0.05	0.09	4.14	3.15	3.28
	70.77			3.28		
	70.74				0.00	
	70.78					1.16

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 91	S=0.00938	Rock size 2 in.
Q=100 cfs	Temp. 77 F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=.133'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	72.43	0.90	1.61	7.86	8.61	7.96
D=1.786'	72.07	0.70	1.25	7.82	8.32	7.99
	71.71	0.50	0.89	7.51	7.58	7.43
	71.53	0.40	0.71	6.83	7.06	6.91
	71.36	0.30	0.54	6.47	6.34	6.39
	71.18	0.20	0.36	5.63	5.91	5.86
	71.09	0.15	0.27	5.38	5.77	5.48
	71.00	0.10	0.18	4.52	5.23	5.12
	70.91	0.05	0.09	3.59	4.33	4.08
	70.81			1.04		
	70.82				4.14	
	70.79					1.27
X=130'	72.43	0.90	1.63	7.79	8.82	7.82
D=1.806'	72.07	0.70	1.26	7.89	8.16	8.16
	71.71	0.50	0.90	7.51	7.68	7.61
	71.53	0.40	0.72	7.29	7.47	7.18
	71.35	0.30	0.54	6.83	6.60	6.51
	71.17	0.20	(ft)	6.00	5.72	5.90
	71.08	0.15	0.27	5.28	5.23	5.58
	70.99	0.10	0.18	4.91	4.91	4.57
	70.90	0.05	0.09	4.33	4.52	3.80
	70.85			3.73		
	70.70				1.04	
	70.73					2.07

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 92	S=0.01084	Rock size 2 in.
Q=100 cfs	Temp. 77 F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=.133'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	72.36	0.90	1.54		9.18	
D=1.714'	72.19	0.80	1.37	8.48	8.45	8.51
	72.02	0.70	1.20		7.96	
	71.68	0.50	0.86		7.03	
	71.51	0.40	0.69		6.75	
	71.33	0.30	0.51		6.08	
	71.16	0.20	0.34	5.95	5.72	6.26
	71.08	0.15	0.26		5.08	
	70.99	0.10	0.17		4.52	
	70.91	0.05		0.00		
	70.71				4.01	
	70.84					1.04
	70.72					
X=130'	72.37	0.90	1.56		8.97	
D=1.733'	72.19	0.80	1.39	8.26	8.35	8.51
	72.02	0.70	1.21		7.92	
	71.67	0.50	0.87		7.14	
	71.49	0.40	0.69		6.59	
	71.33	0.30	0.52		5.81	
	71.15	0.20	0.35	6.22	5.38	6.87
	71.07	0.15	0.26		5.02	
	70.98	0.10	0.17		4.46	
	70.89	0.05		3.74		
	70.82				0.00	
	70.74					3.28
	70.78					
X=140'	72.32	0.90	1.52		9.41	
D=1.685'	72.15	0.80	1.35	8.48		8.70
	71.98	0.70	1.18		8.91	
	71.64	0.50	0.84		8.19	
	71.47	0.40	0.67		7.68	
	71.31	0.30	0.51		7.06	
	71.14	0.20	0.34	6.22	5.86	6.43
	71.05	0.15	0.25		5.53	
	70.97	0.10	0.17		4.63	
	70.88	0.05	0.08		3.88	
	70.73			2.20		
	70.76				3.36	
	70.73					3.11

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 93	S=0.01189	Rock size 2 in.
Q=100 cfs	Temp. 75 F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	72.32	0.90	1.50		9.55	
D=1.663'	72.15	0.80	1.33	8.32		8.50
	71.98	0.70	1.16		8.97	
	71.65	0.50	0.83		8.29	
	71.49	0.40	0.67		7.54	
	71.32	0.30	0.50		6.91	
	71.15	0.20	0.33	6.02	6.22	5.60
	71.07	0.15	0.25		5.72	
	70.99	0.10	0.17		5.43	
	70.90	0.05	0.08		4.91	
	70.75			2.59		
	70.75				3.80	
	70.76					2.48
X=130'	72.35	0.90	1.54		9.15	
D=1.714'	72.18	0.80	1.37	8.32		8.61
	72.01	0.70	1.20		8.57	
	71.60	0.50	0.80		7.86	
	71.49	0.40	0.69		7.25	
	71.32	0.30	0.51		6.71	
	71.15	0.20	0.34	5.97	6.22	6.22
	71.06	0.15	0.26		5.58	
	70.98	0.10	0.17		5.28	
	70.89	0.05	0.09		4.21	
	70.82			1.55		
	70.80				3.66	
	70.76					1.79
X=140'	72.34	0.90	1.55		9.21	
D=1.716'	72.17	0.80	1.38	8.51		8.73
	72.00	0.70	1.21		8.61	
	71.66	0.50	0.86		8.02	
	71.49	0.40	0.69		7.43	
	71.31	0.30	0.52		6.71	
	71.14	0.20	0.35	6.06	5.91	6.24
	71.06	0.15	0.26		5.43	
	70.97	0.10	0.18		4.75	
	70.89	0.05	0.09		4.08	
	70.98			4.33		
	70.76				2.54	
	70.81					1.16

CORPS OF ENGINEERS RIPRAP PROJECT

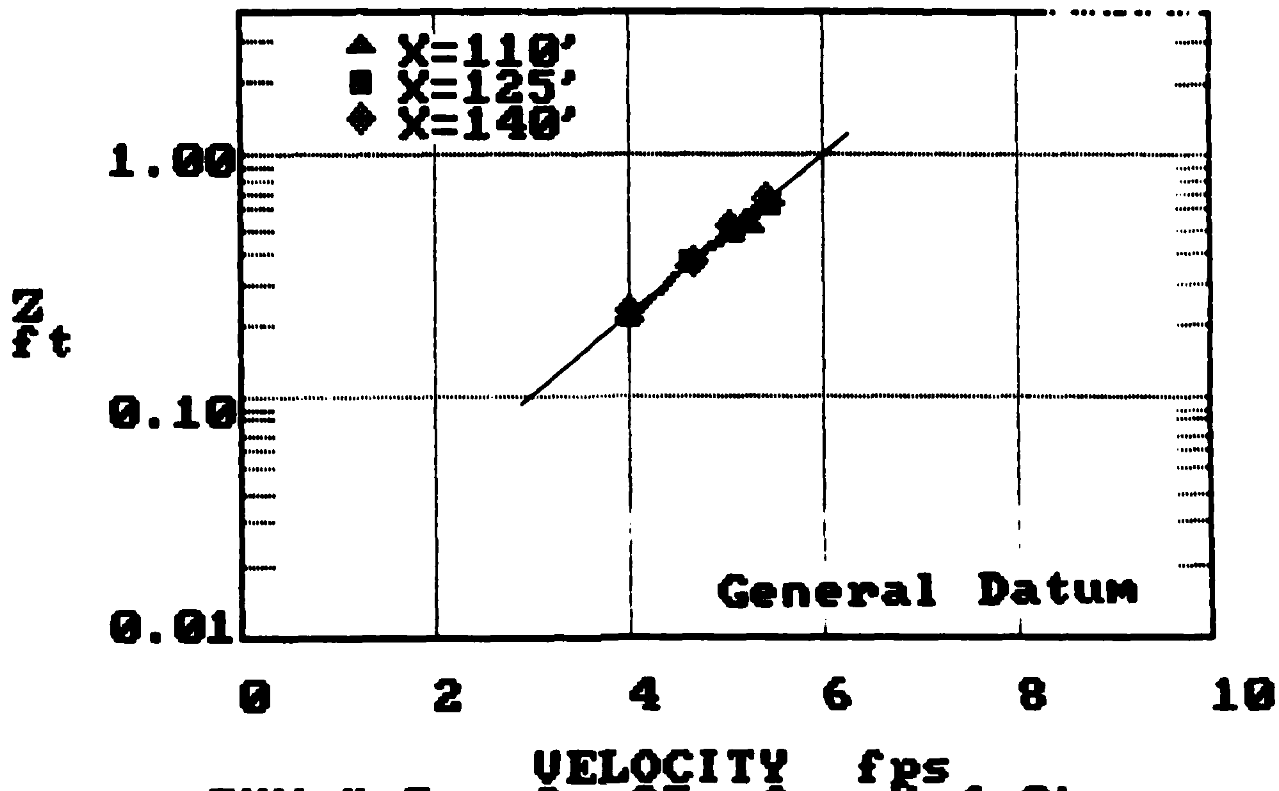
Run # 94	S=0.01300	Rock size 2 in.
Q=100 cfs	Temp. 75 F	Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	72.24	0.90	1.42		10.00	
D=1.572'	72.08	0.80	1.26	9.21		9.27
	71.92	0.70	1.10		9.21	
	71.61	0.50	0.79		8.67	
	71.45	0.40	0.63		8.29	
	71.29	0.30	0.47		7.33	
	71.13	0.20	0.31	6.63	6.34	6.55
	71.06	0.15	0.24		6.22	
	70.98	0.10	0.16		5.72	
	70.90	0.05	0.08		5.13	
	70.73			2.32		
	70.76				2.93	
	70.63					0.00

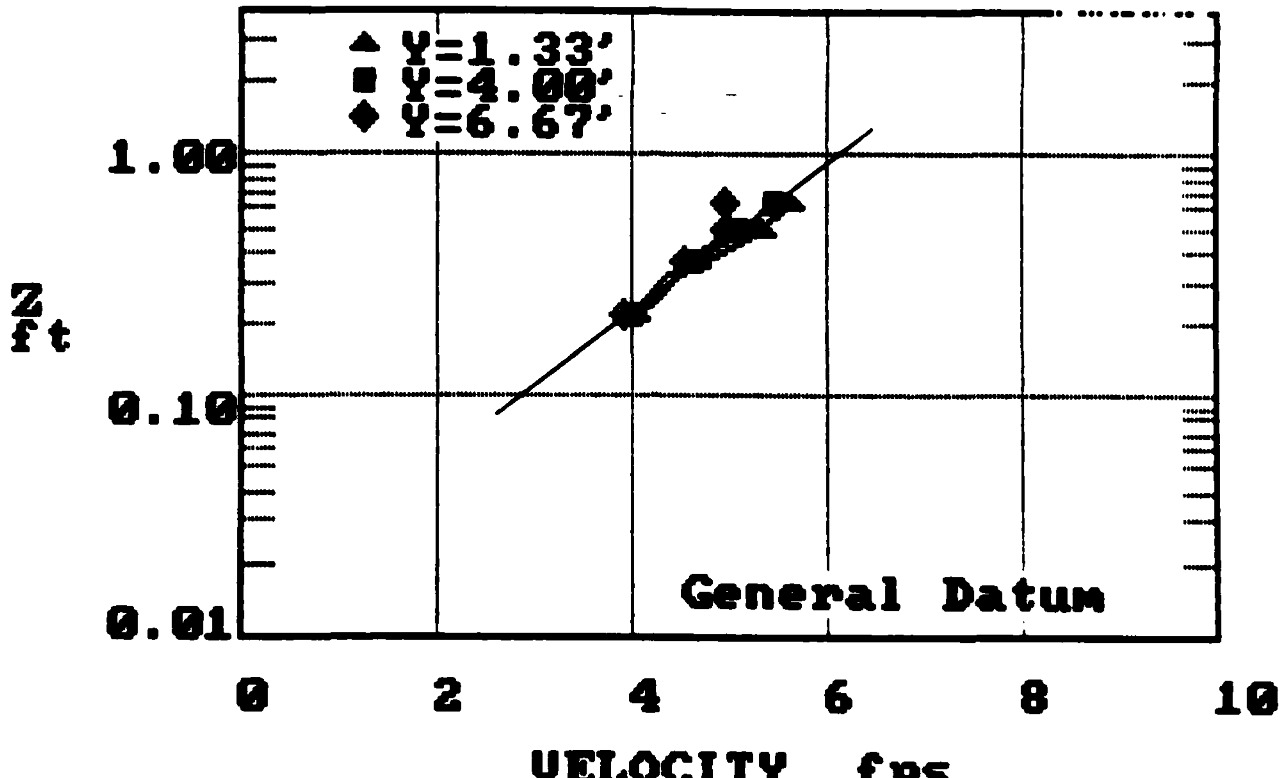
APPENDIX C

VELOCITY PROFILES

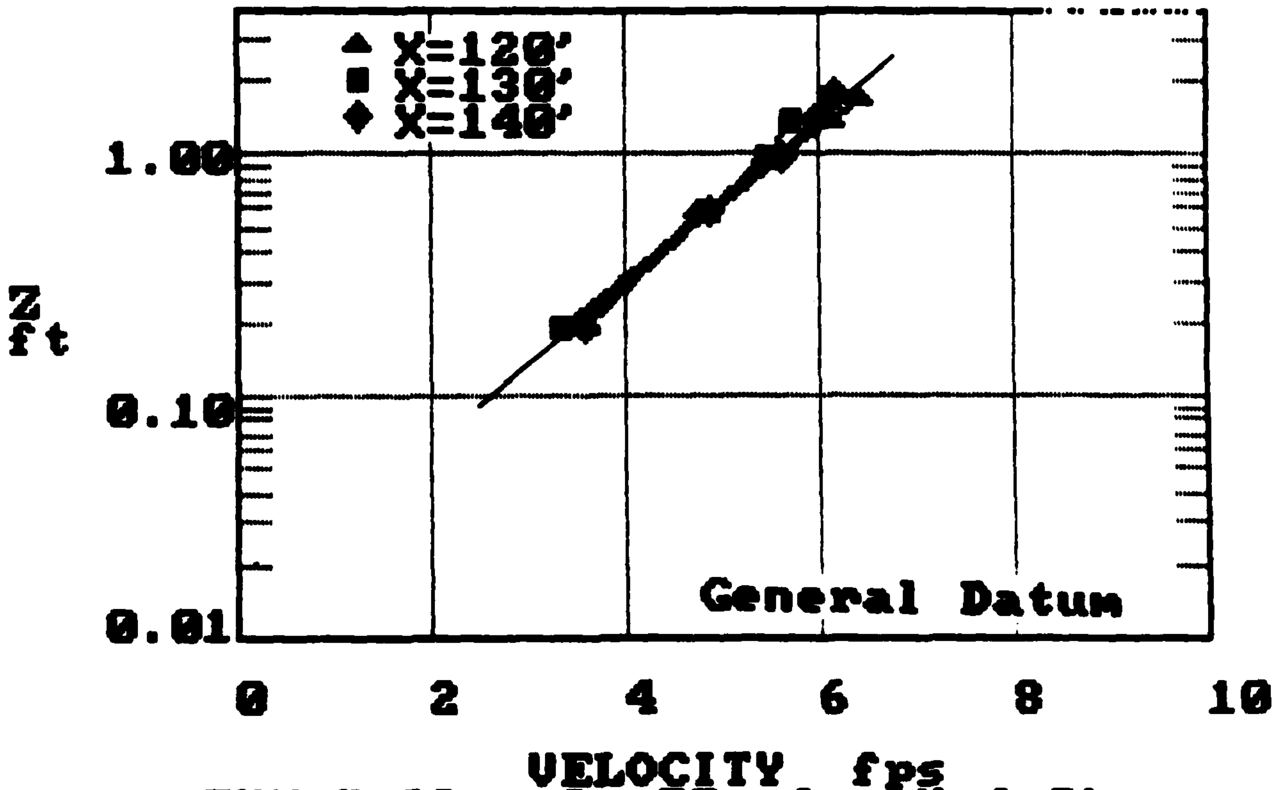
Test Series #	Riprap Size in.	Riprap Thickness in.	Run Numbers
1	1	2	7, 23, 27, 31
2	1	2	37, 40, 41, 45
3	1	3	56, 57, 60, 64
4	2	4	67, 72, 74, 76
5	2	6	84, 88, 93



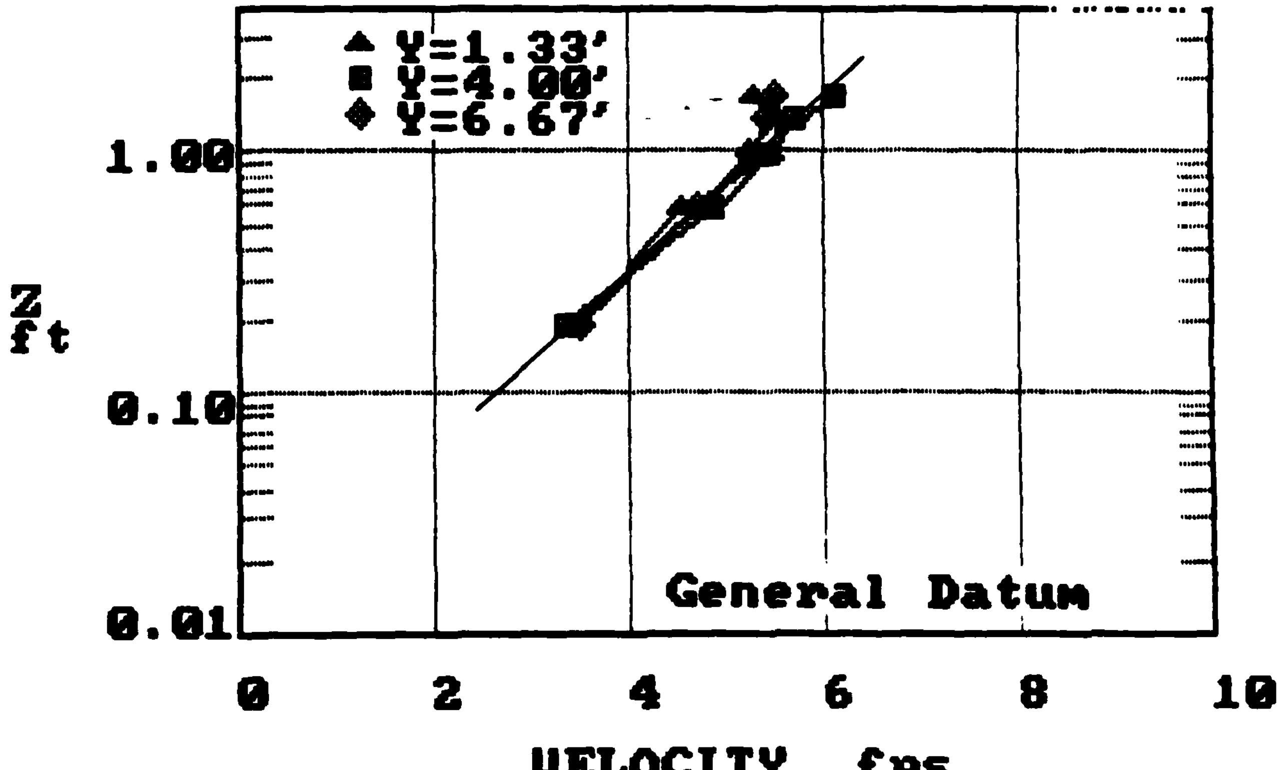
RUN # 7 , Q= 25 cfs, Y=4.0'



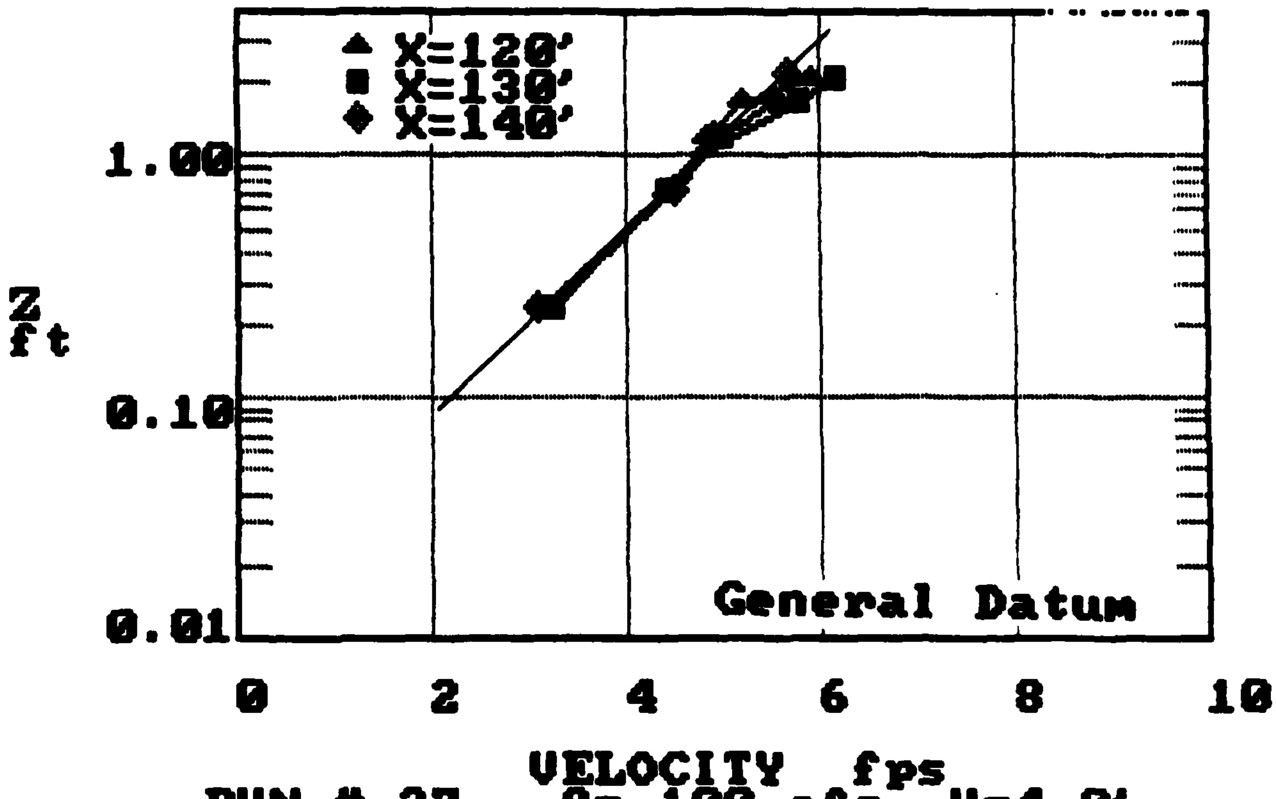
RUN # 7 , Q= 25 cfs, X=125'



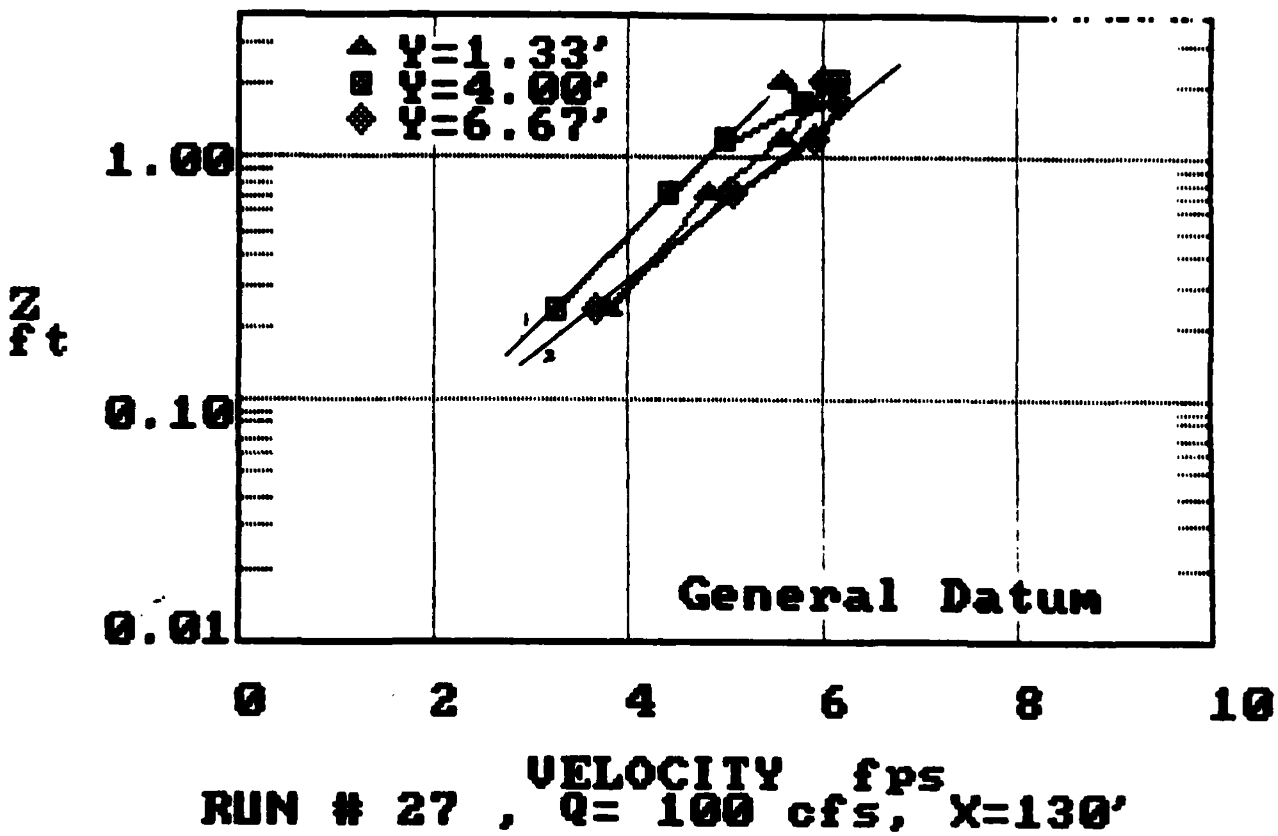
RUN # 23 , Q= 75 cfs, Y=4.0'

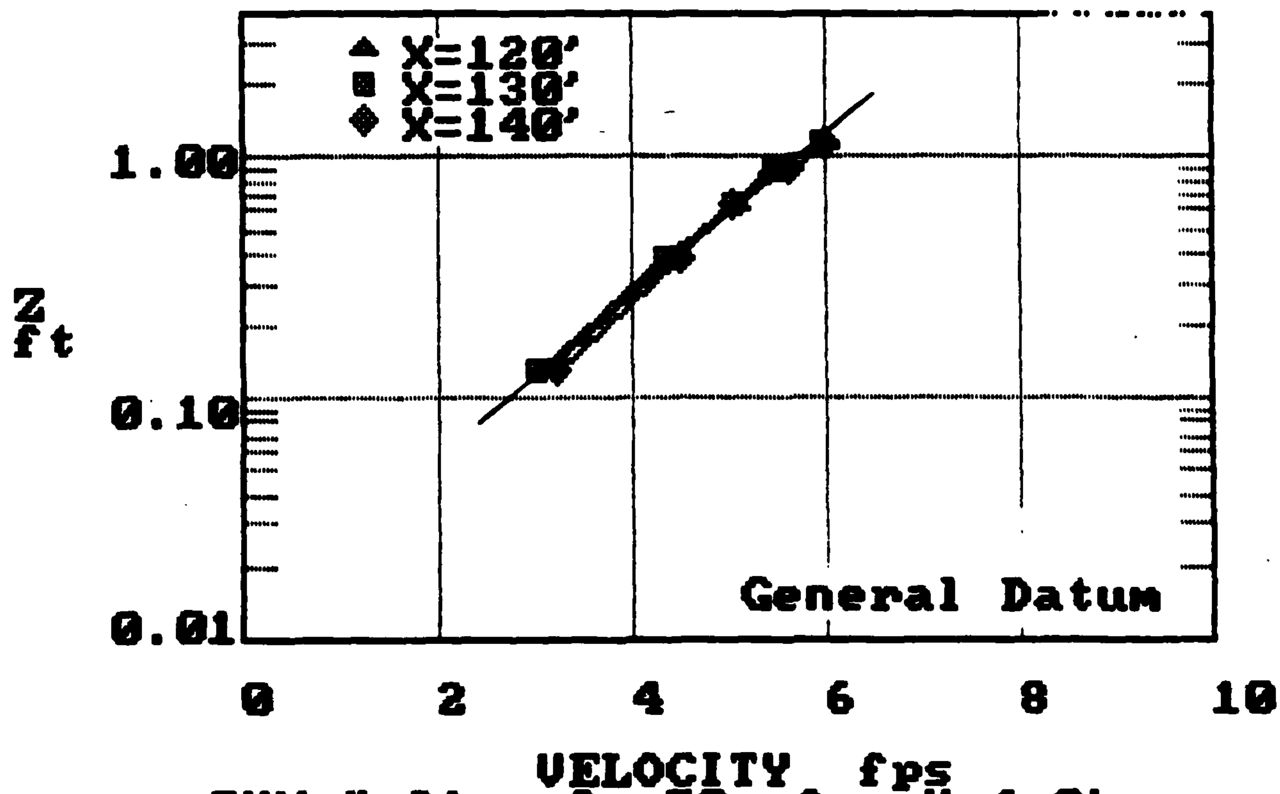


RUN # 23 , Q= 75 cfs, X=130'

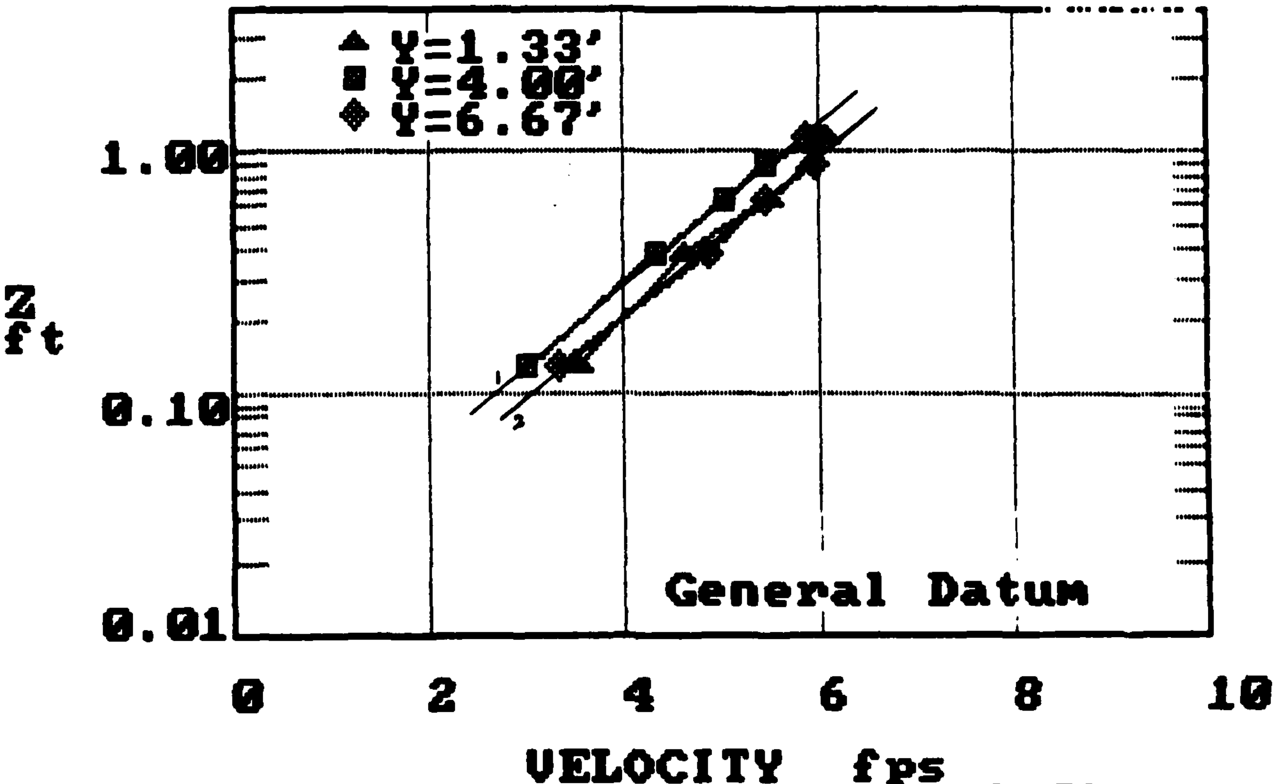


RUN # 27 , Q= 100 cfs, Y=4.0'

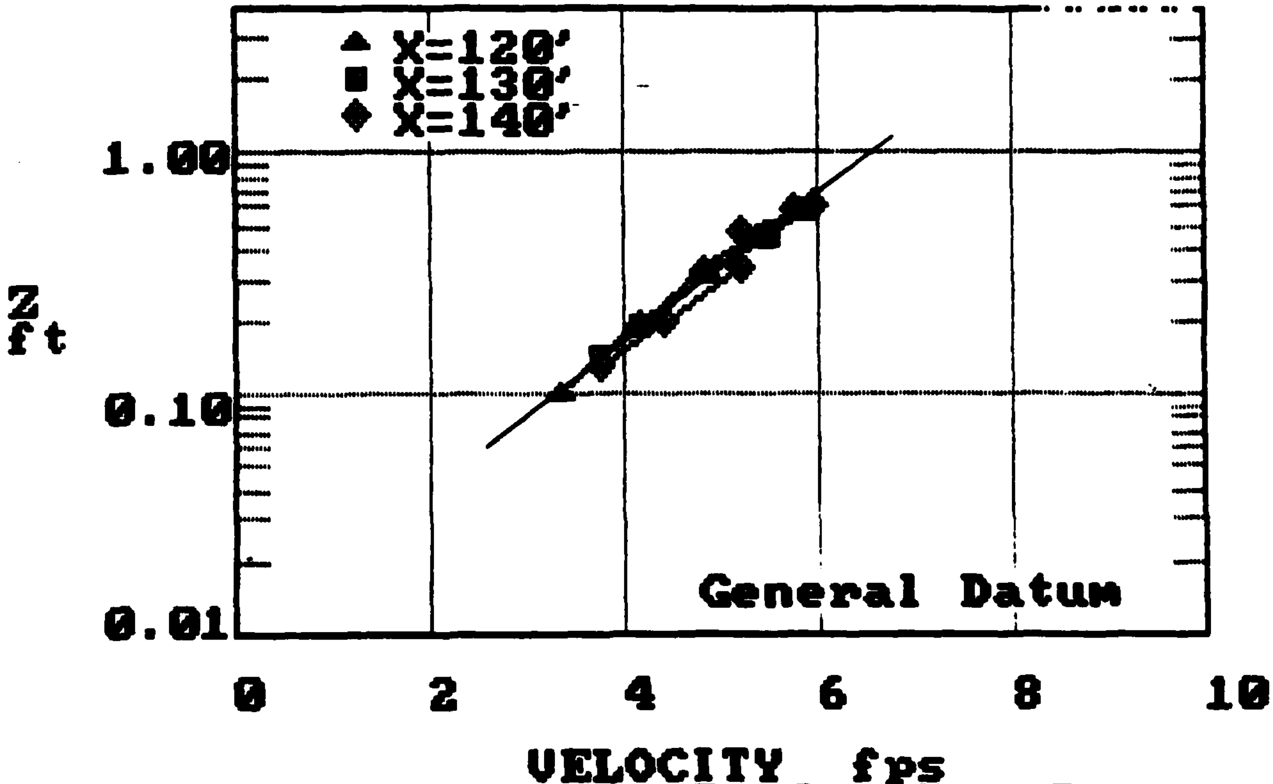

Y=1.33'
Y=4.00'
Y=6.67'
1.00
0.10
0.01
Z
ft
General Datum
0
2
4
6
8
10
VELOCITY fps
RUN # 27 , Q= 100 cfs, X=130'



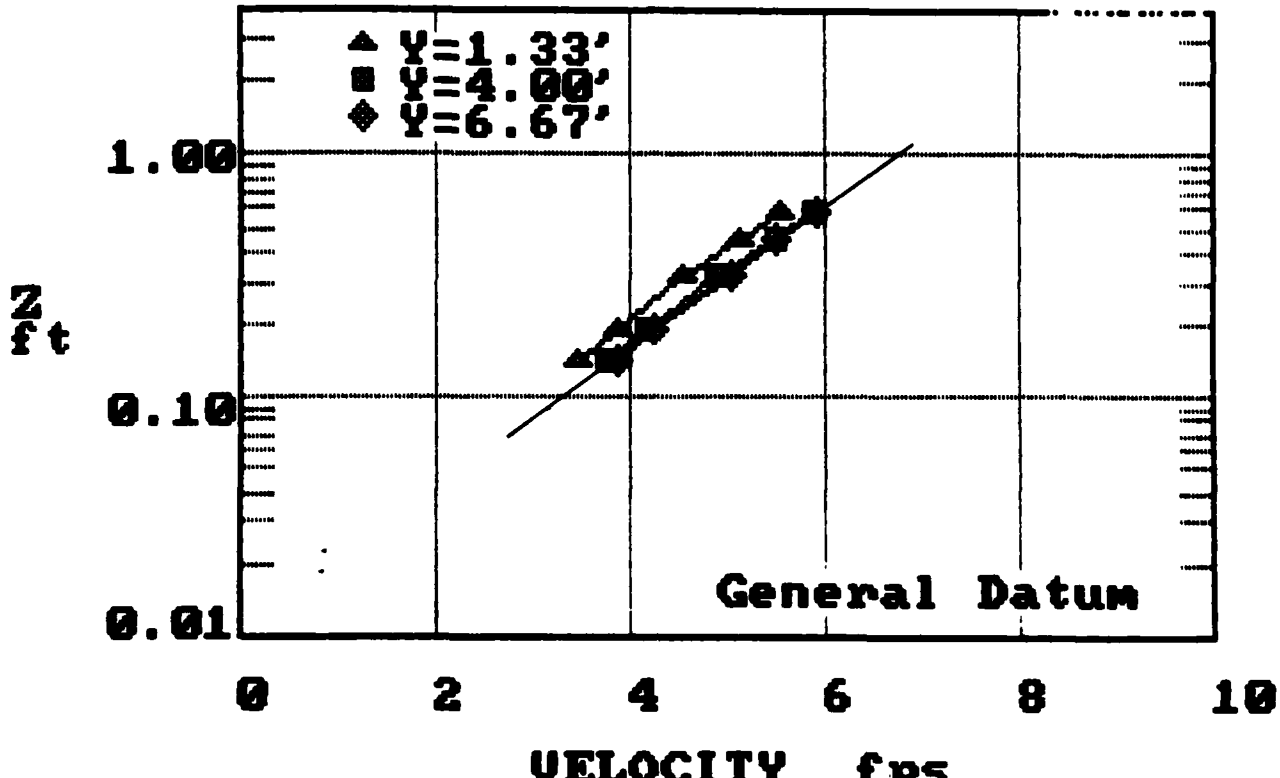
RUN # 31 , Q= 50 cfs, Y=4.0'



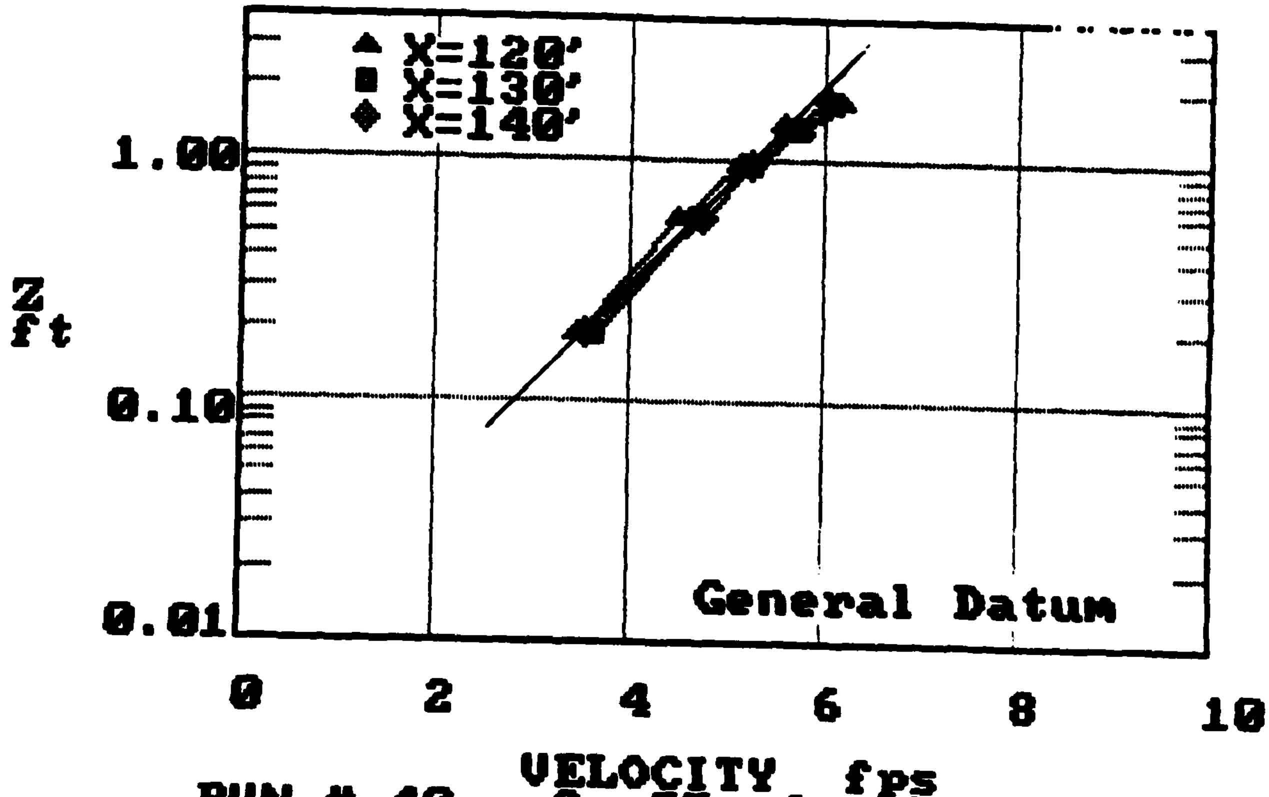
RUN # 31 , Q= 50 cfs, X=130'



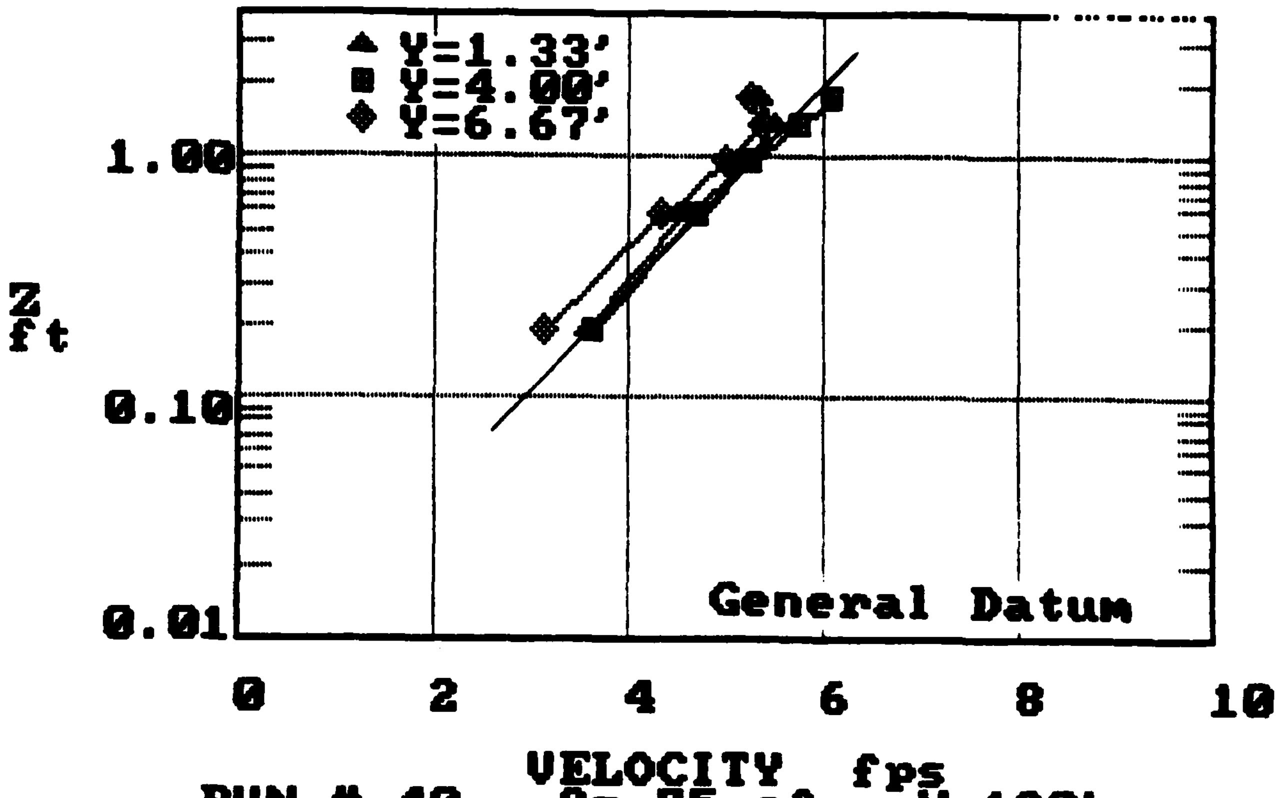
RUN # 37 , Q= 25 cfs, Y=4.0'



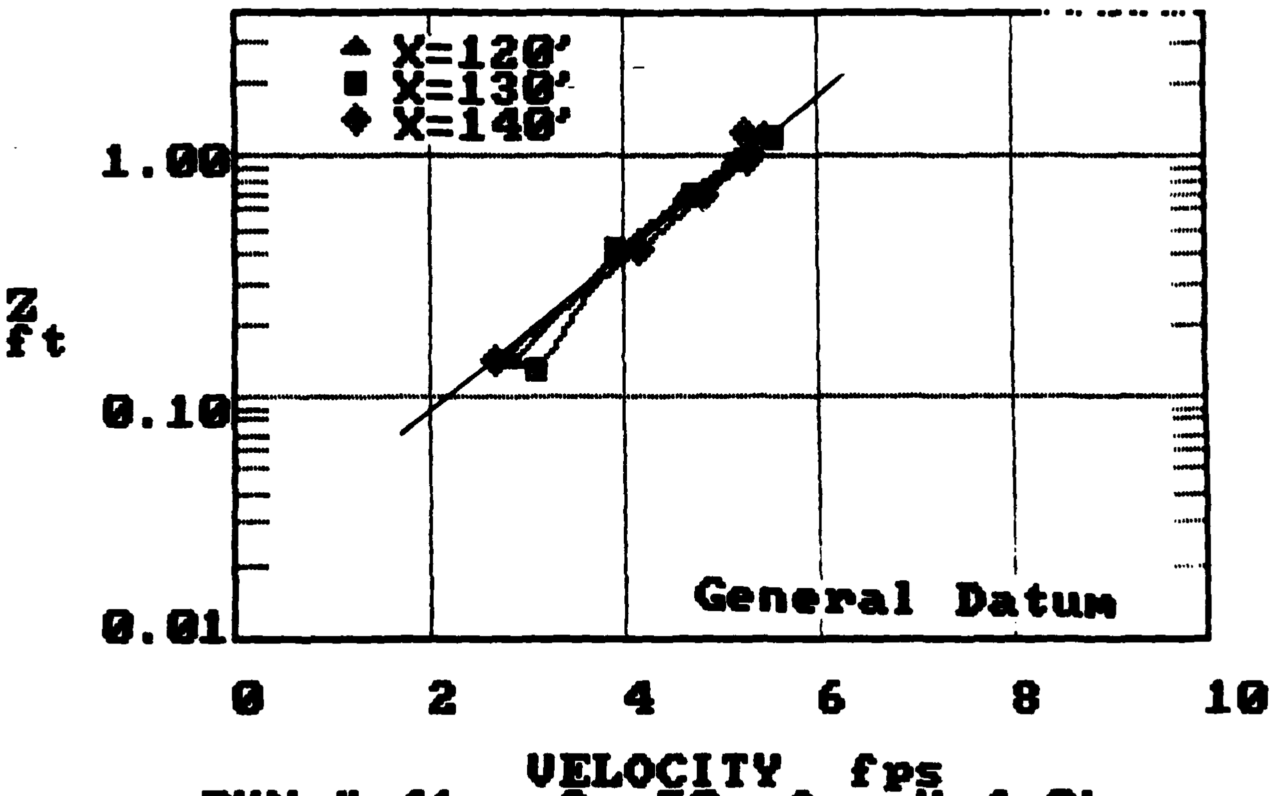
RUN # 37 , Q= 25 cfs, X=130'



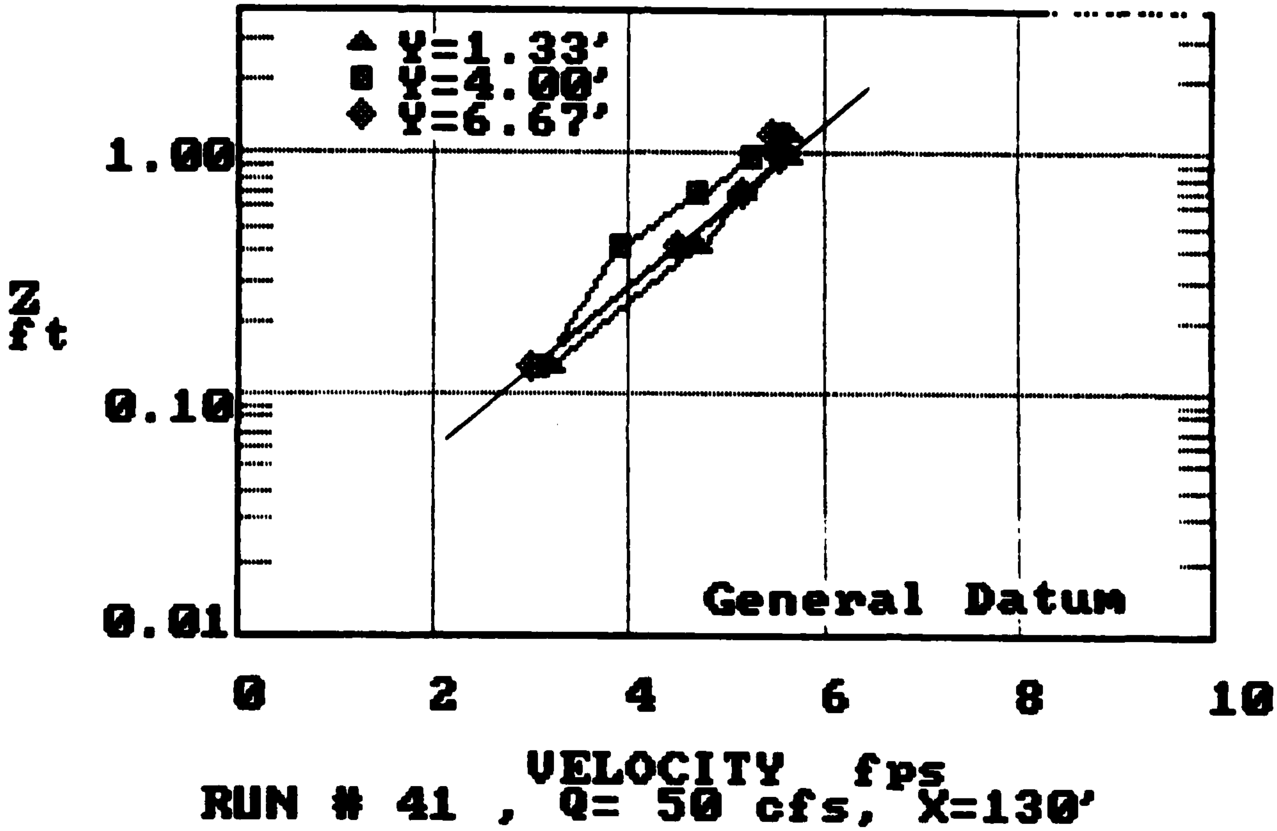
RUN # 40 , Q= 75 cfs, Y=4.0'



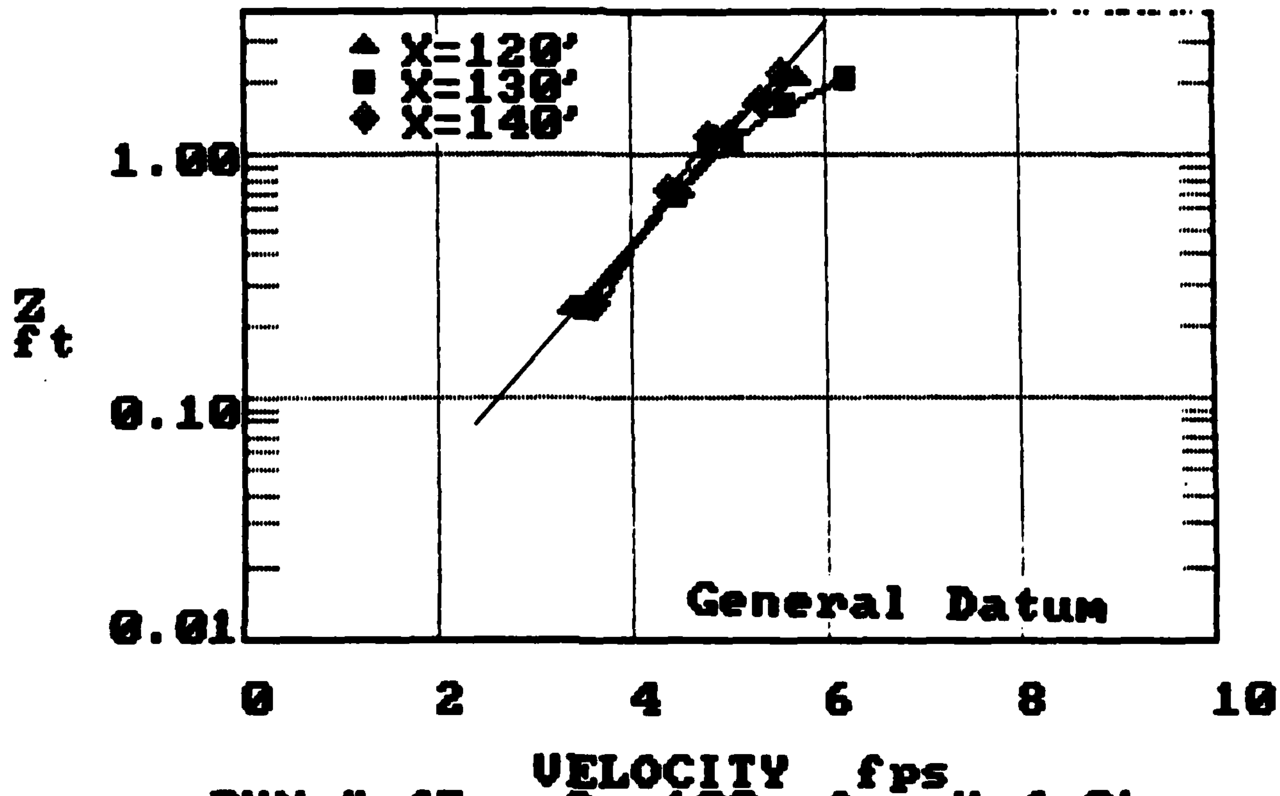
RUN # 40 , Q= 75 cfs, X=130'



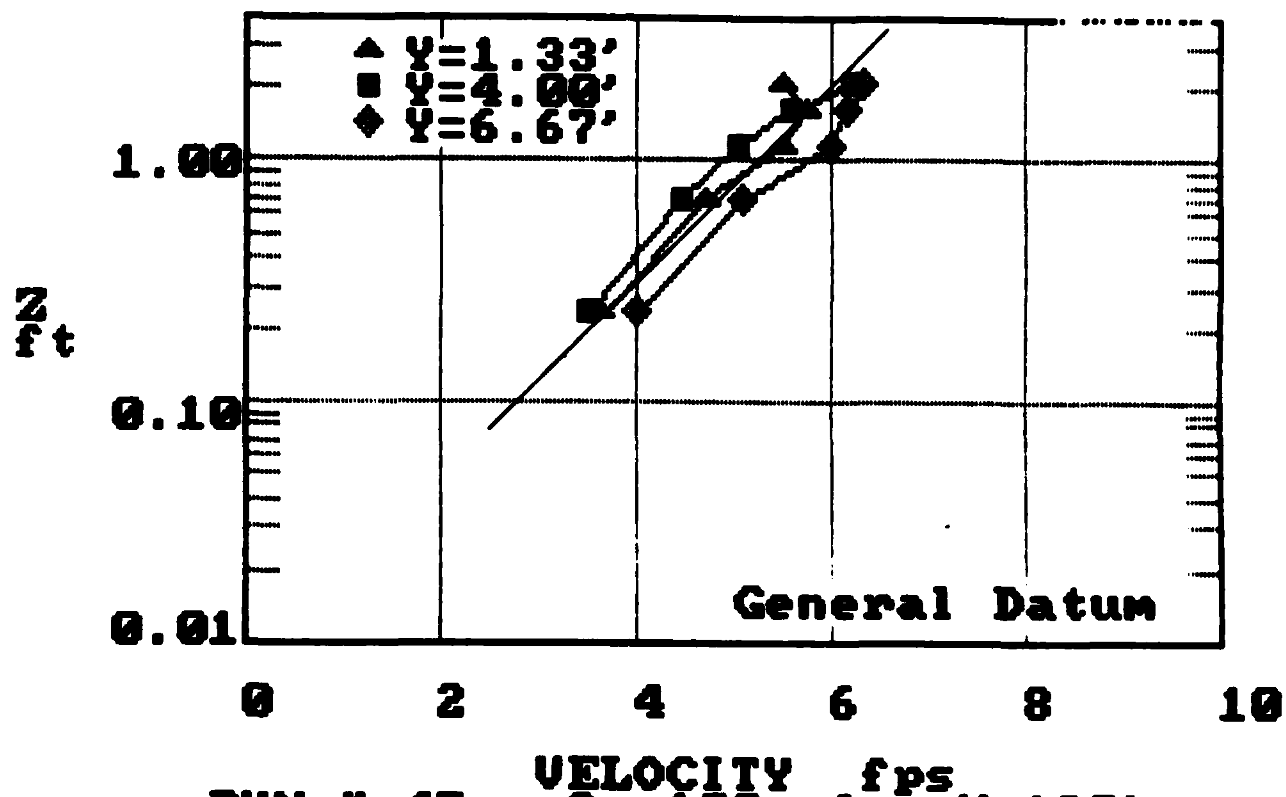
RUN # 41 , Q= 50 cfs, Y=4.0'



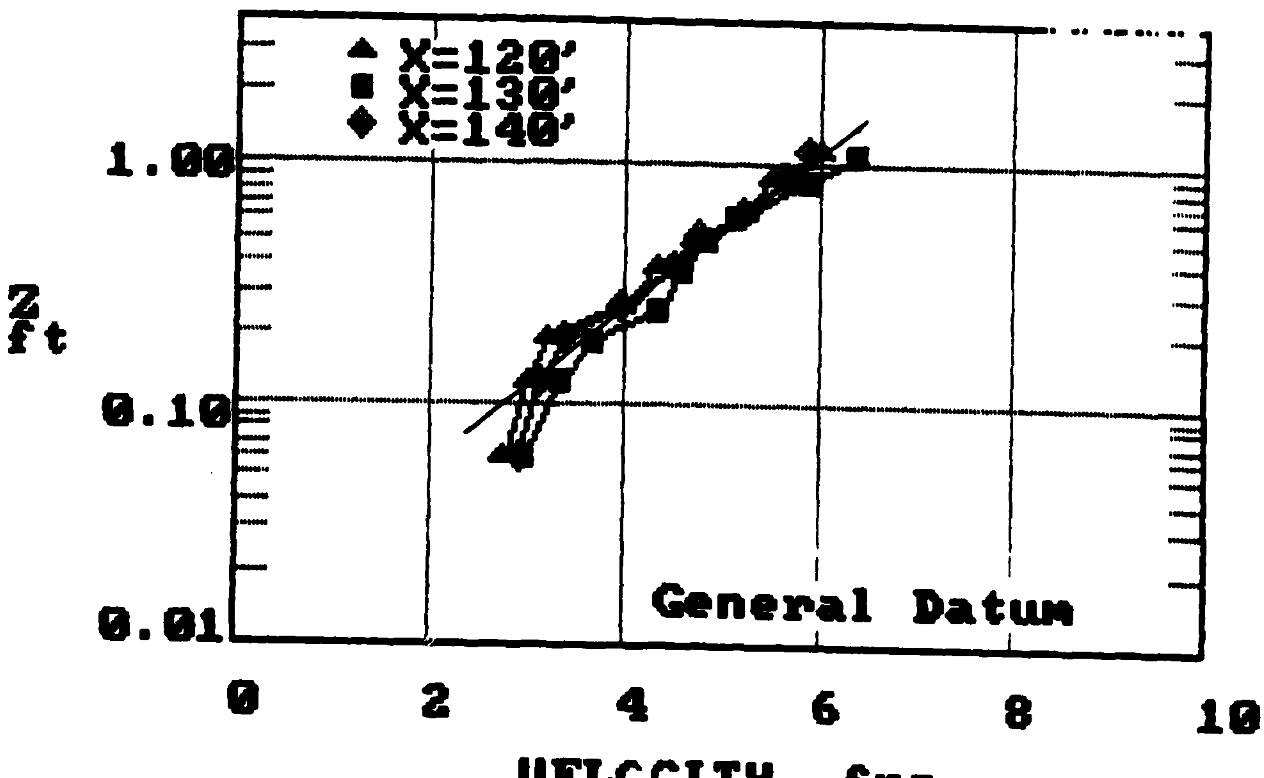
Y=1.33'
Y=4.00'
Y=6.67'
1.00
0.10
0.01
Z
ft
General Datum
0
2
4
6
8
10
VELOCITY fps
RUN # 41 , Q= 50 cfs, X=130'



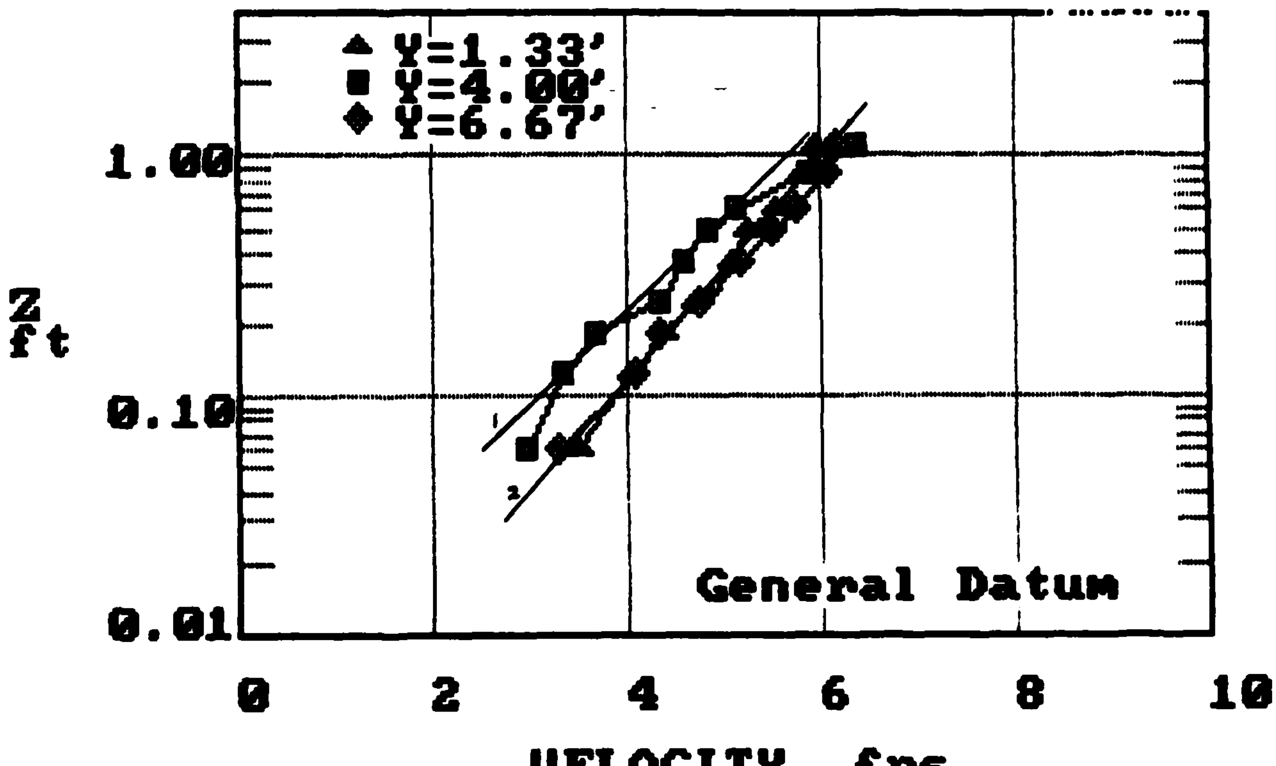
RUN # 45 , Q= 100 cfs, Y=4.0'



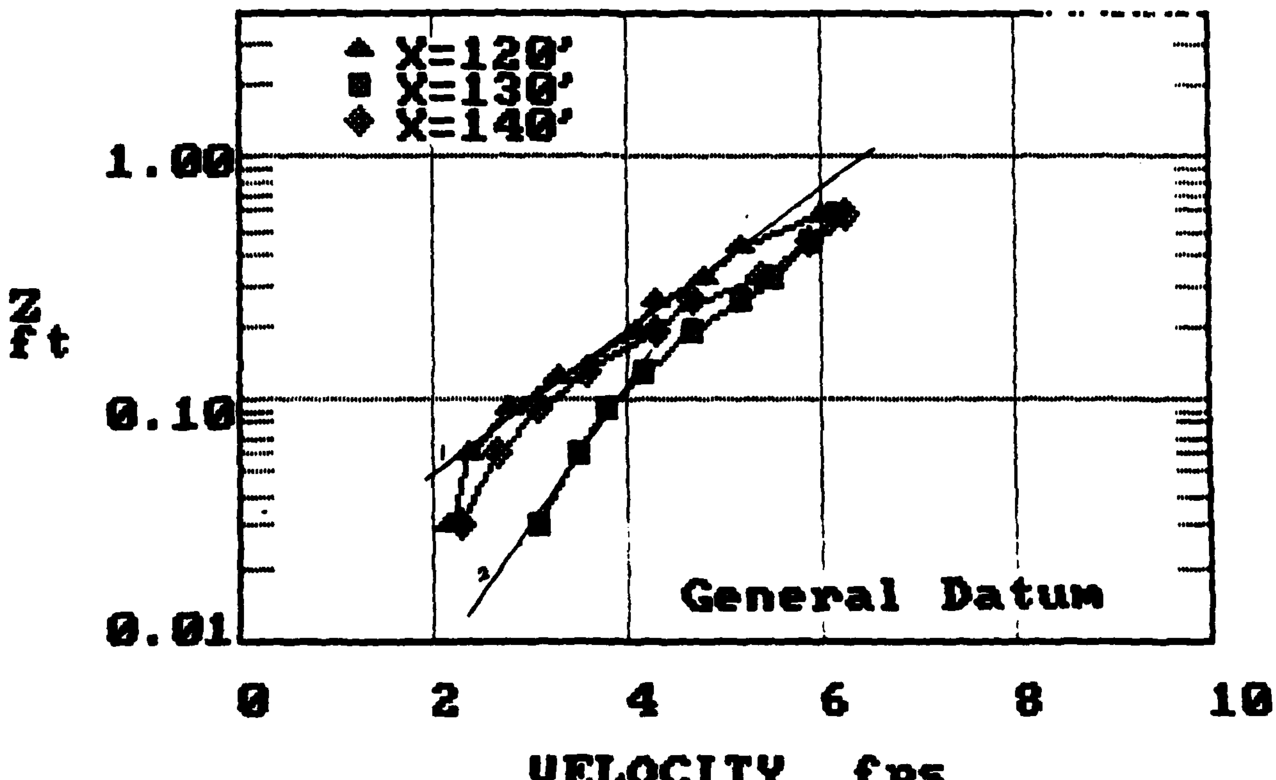
RUN # 45 , Q= 100 cfs, X=130'



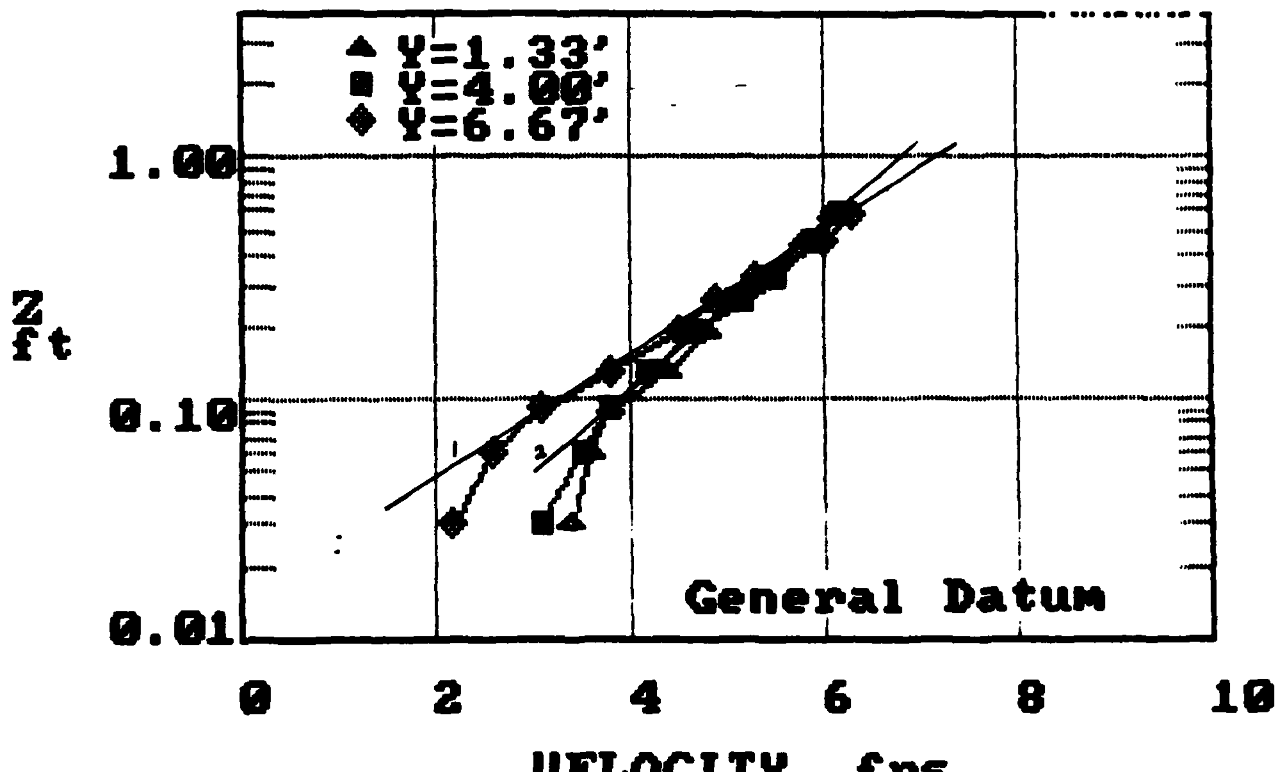
RUN # 56 , Q= 50 cfs, Y=4.0'



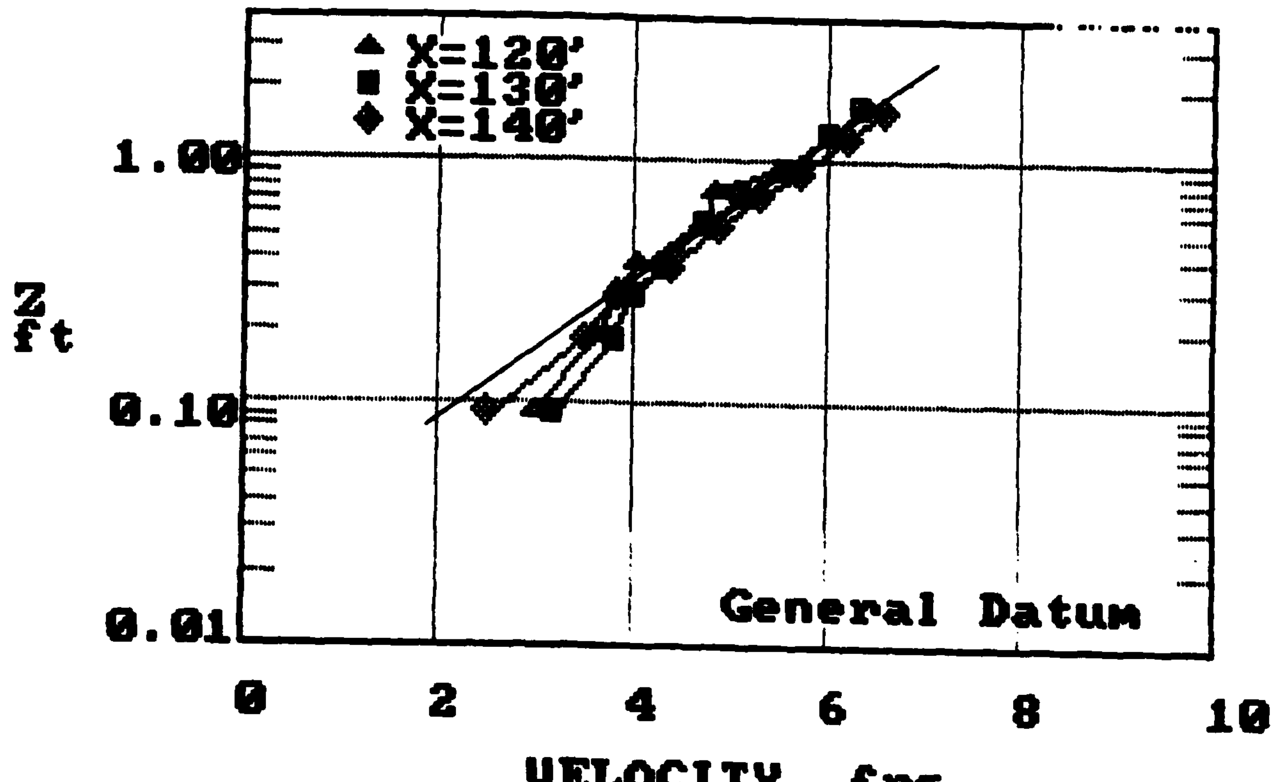
RUN # 56 , Q= 50 cfs, X=130'



RUN # 57 , Q= 25 cfs, Y=4.0'



RUN # 57 , Q= 25 cfs, X=130'



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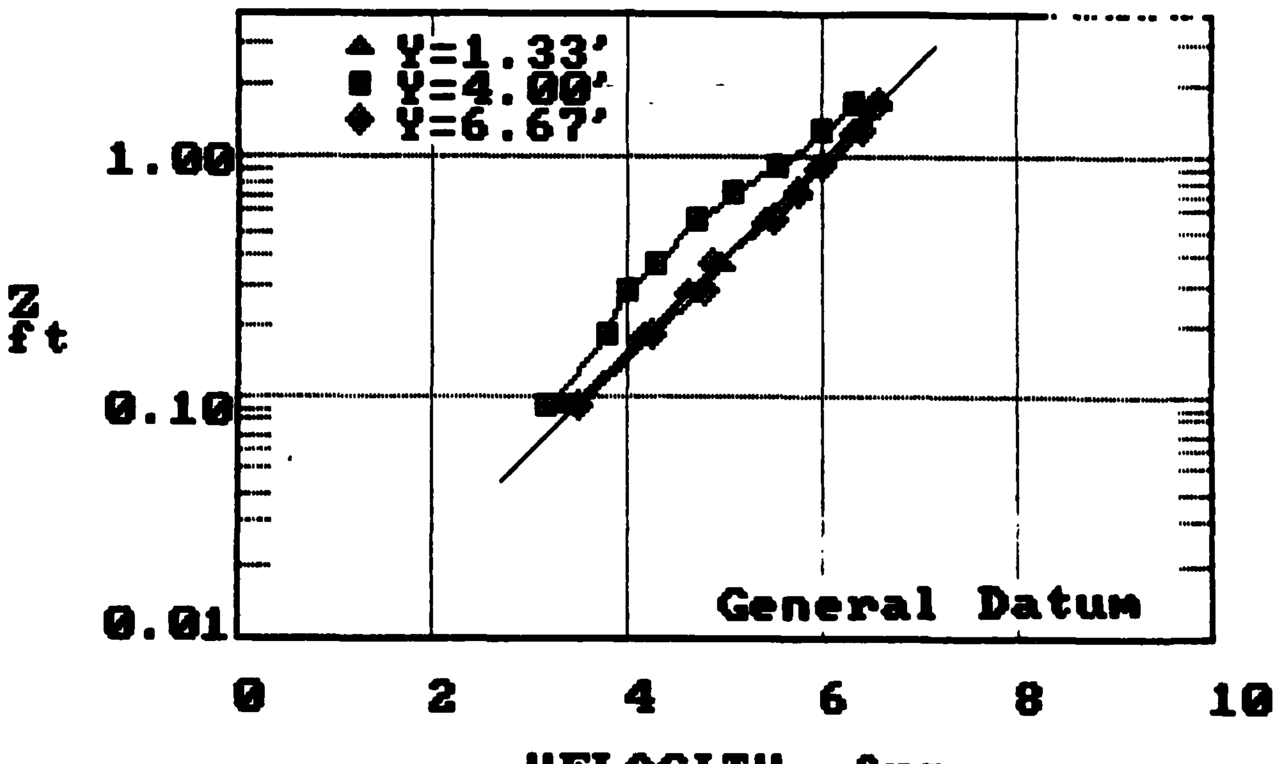
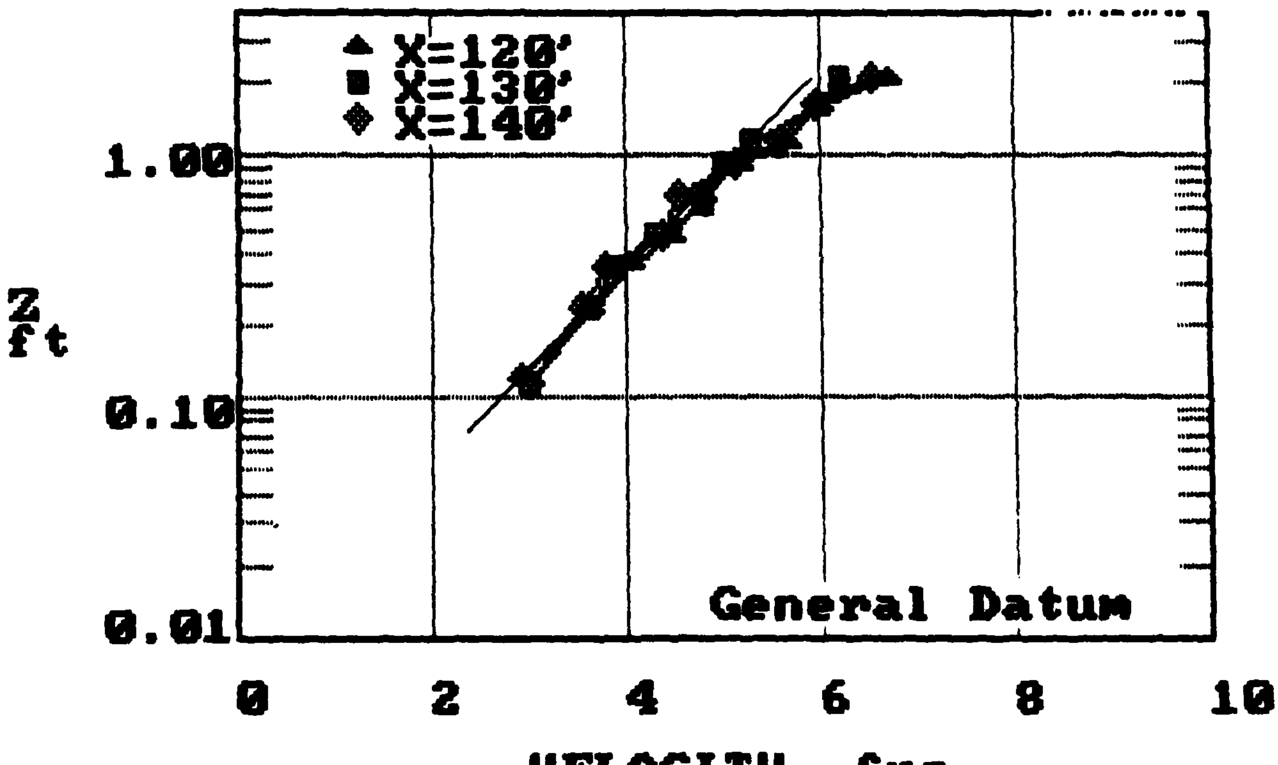
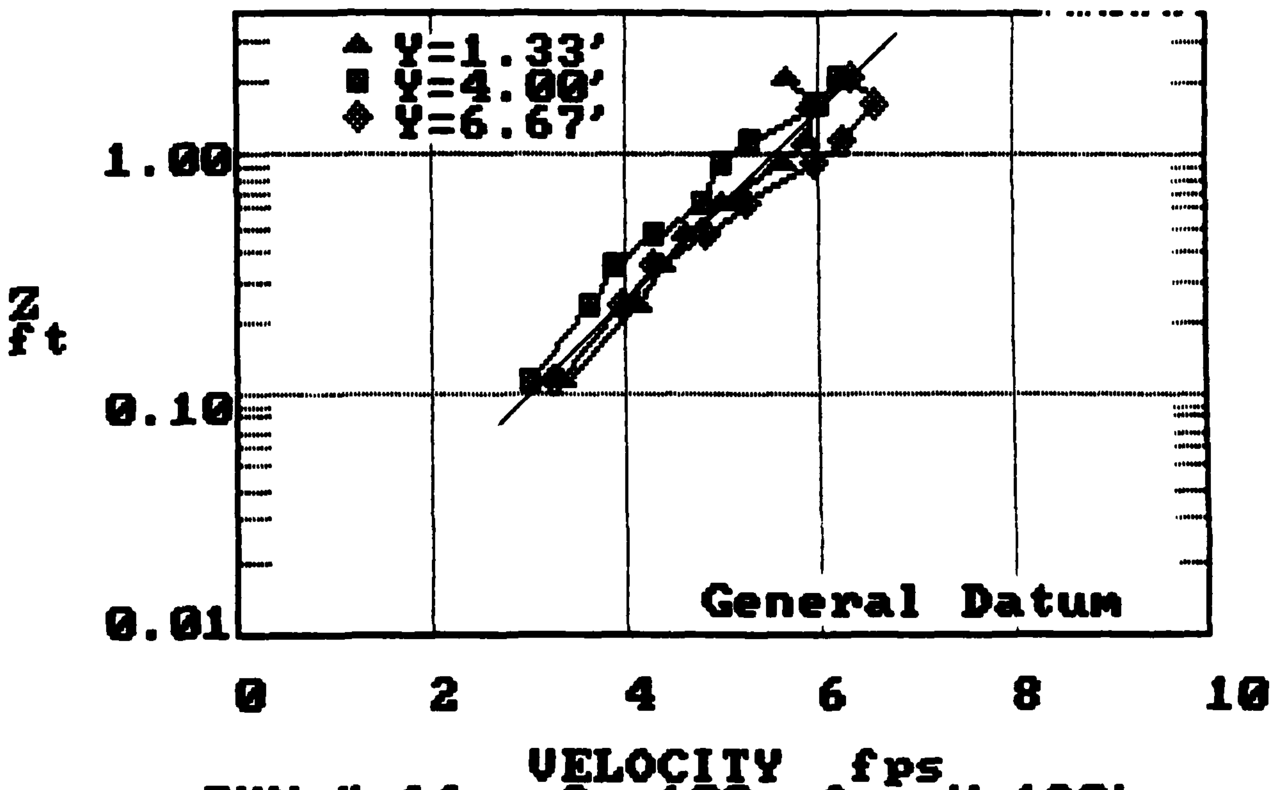


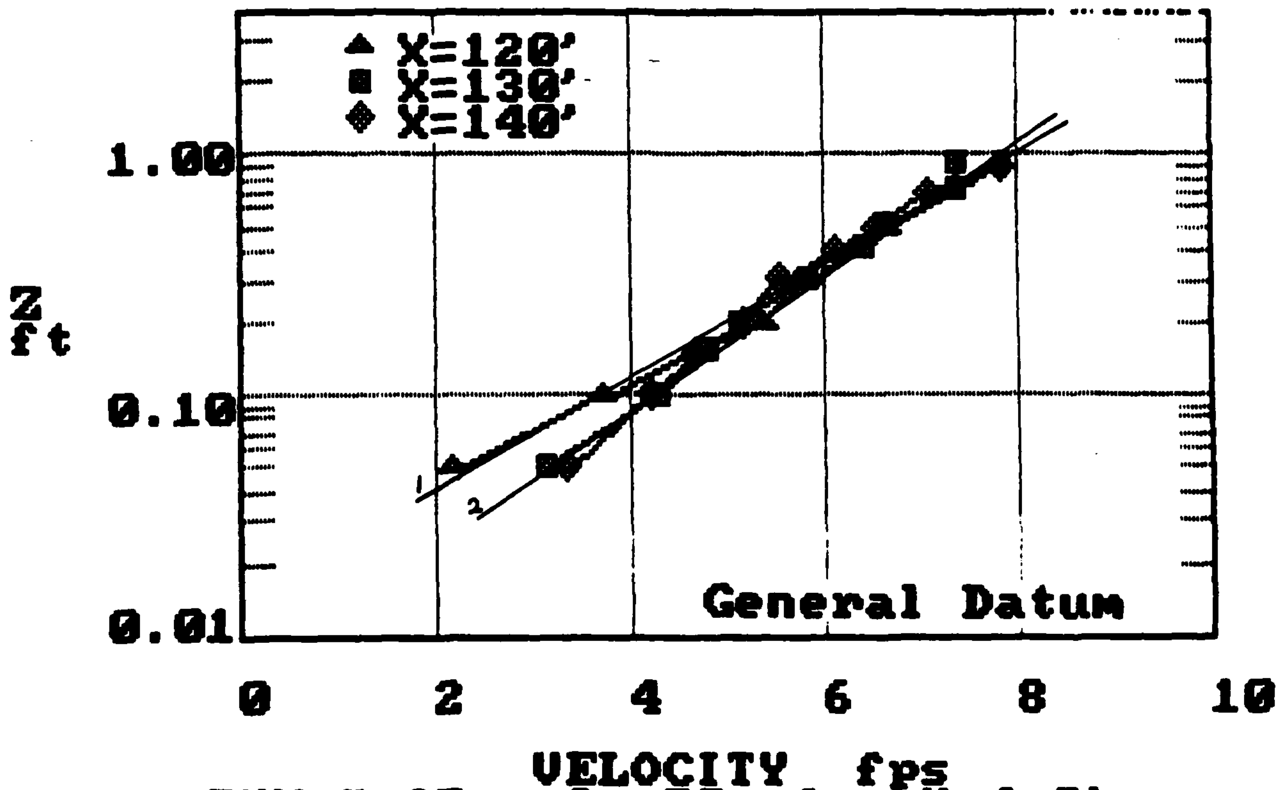
RUN # 60 , Q= 75 cfs, X=130'



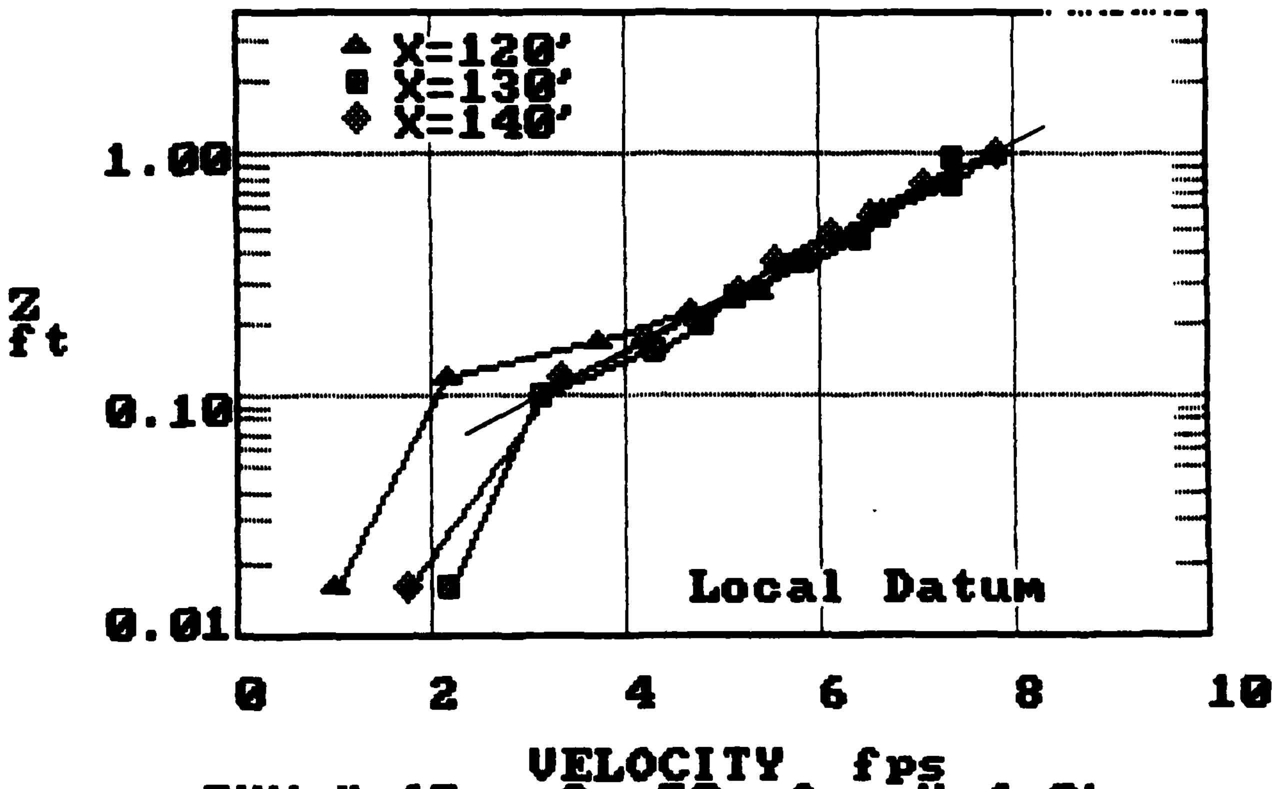
RUN # 64 , Q= 100 cfs, 4.0'



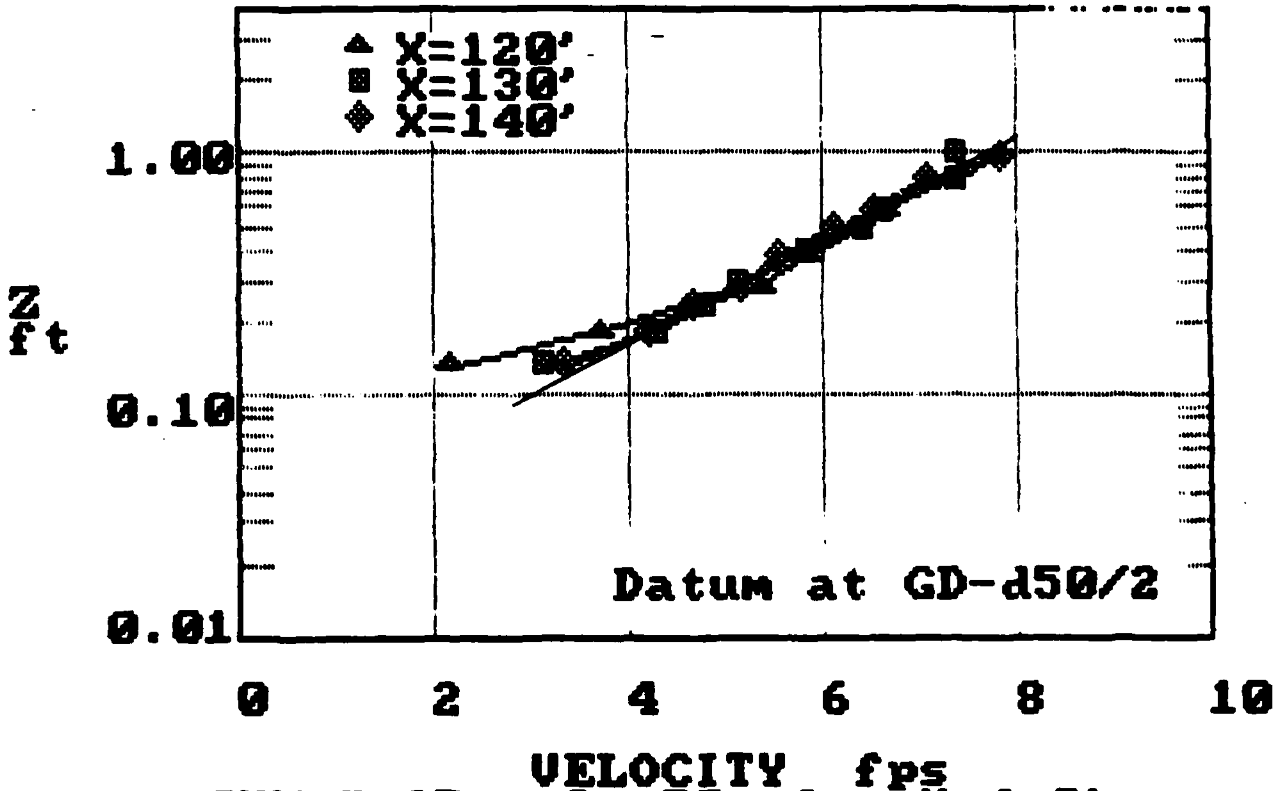
RUN # 64 , Q= 100 cfs, X=130'



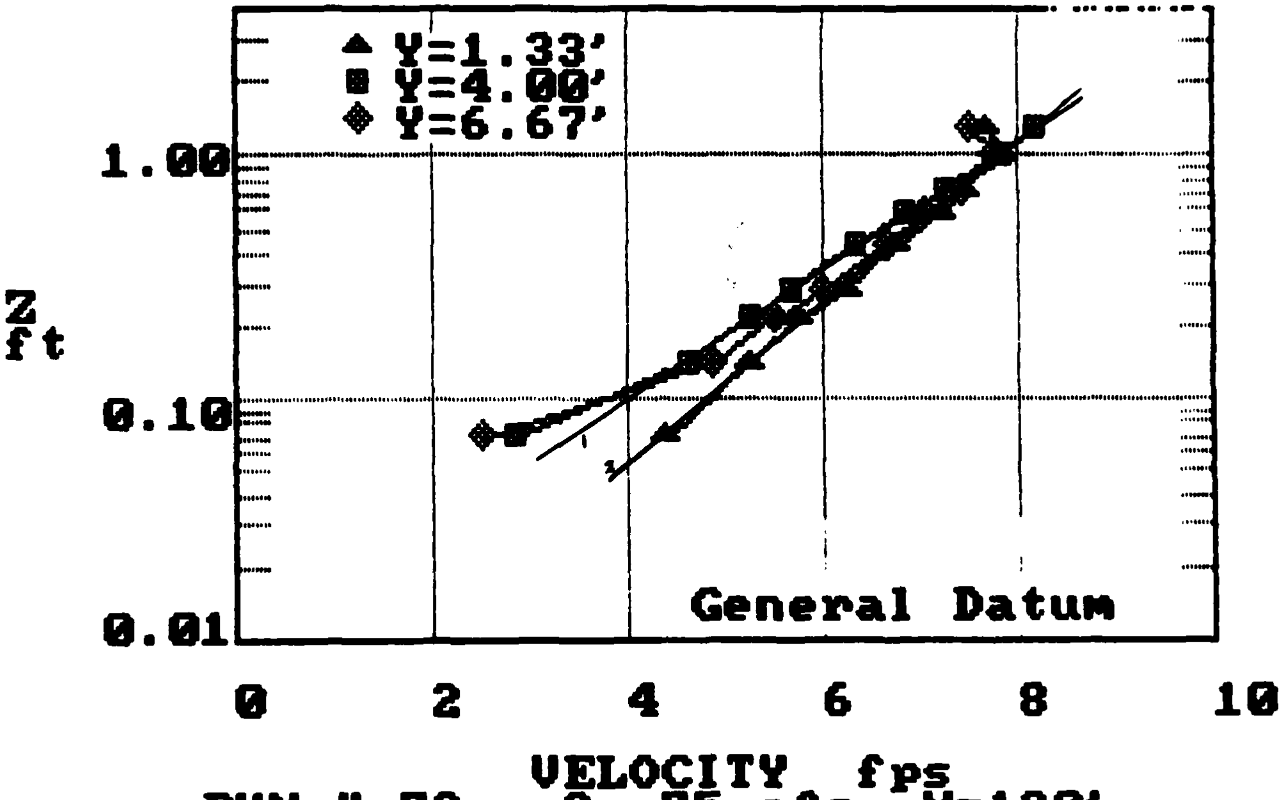
RUN # 67 , Q= 50 cfs, Y=4.0'



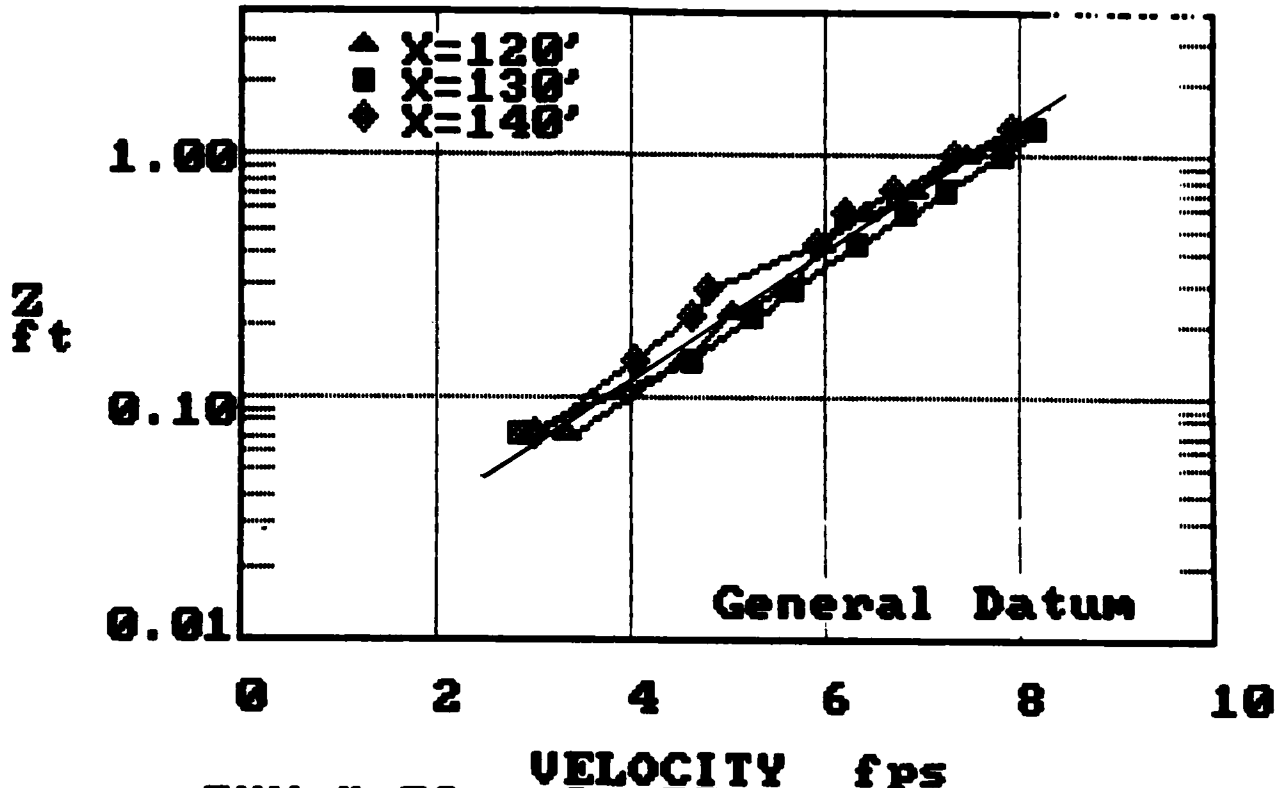
RUN # 67 , Q= 50 cfs, Y=4.0'



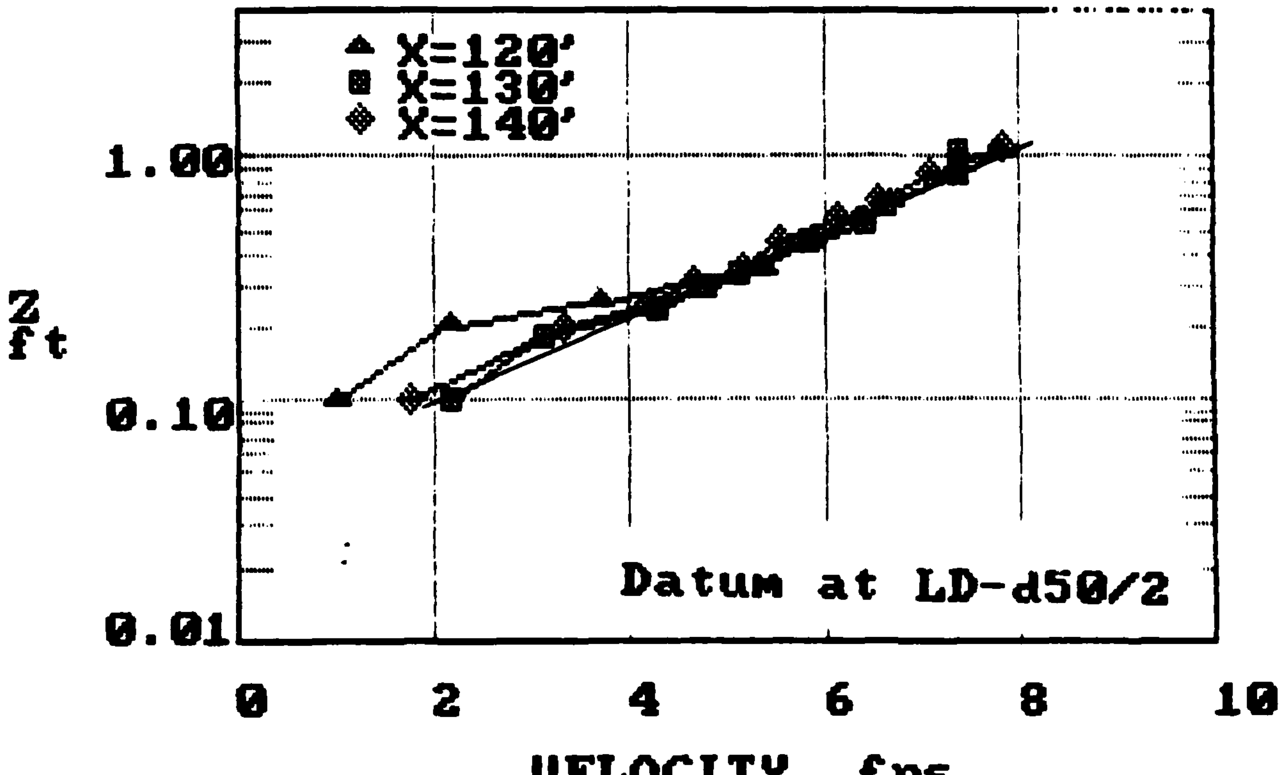
RUN # 67 , Q= 50 cfs, Y=4.0'



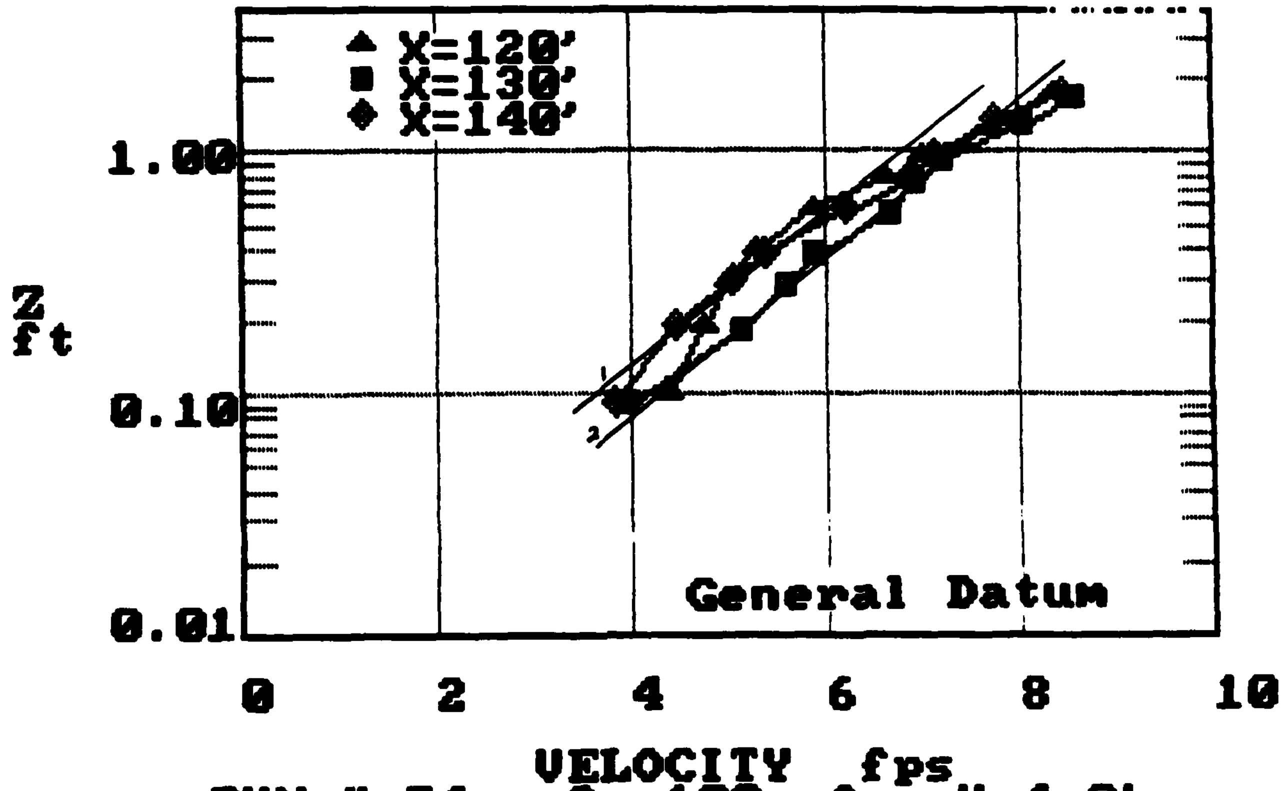
RUN # 72 , Q= 75 cfs, X=130'



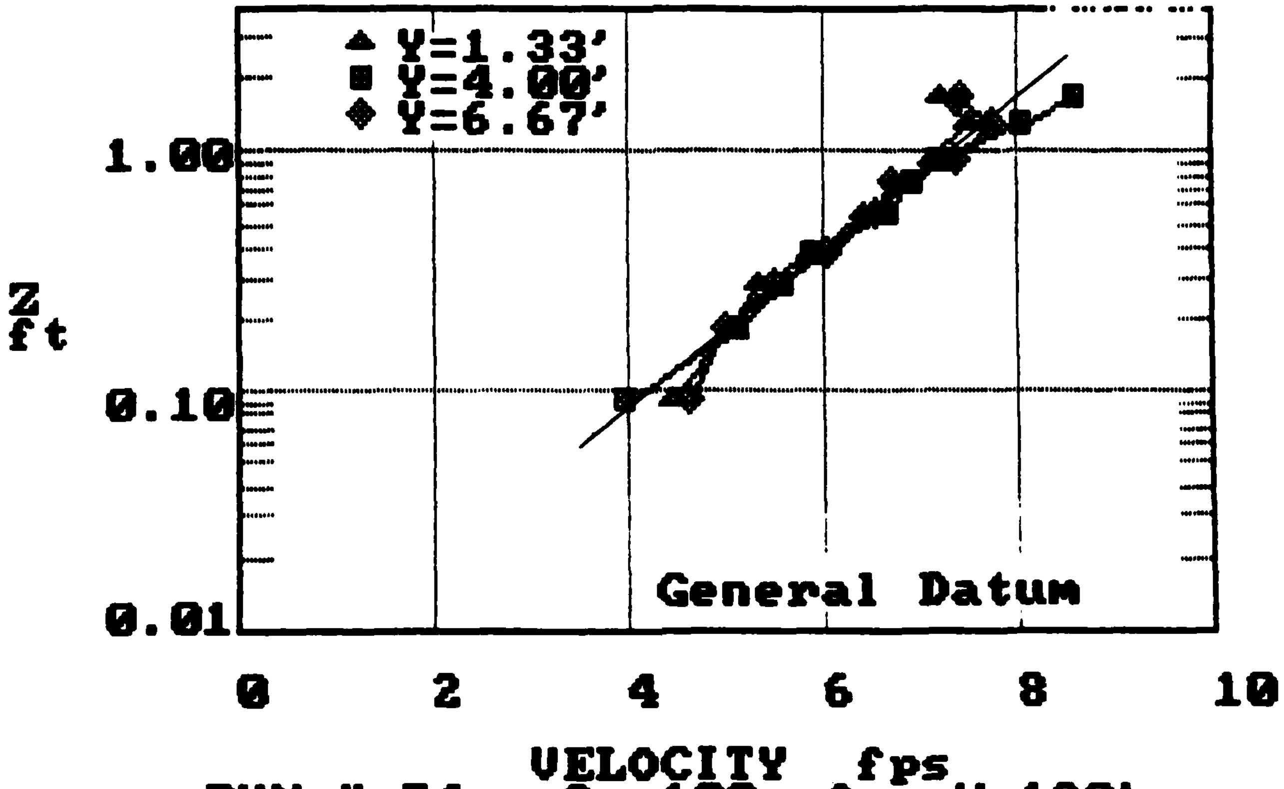
RUN # 72 , Q= 75 cfs, Y=4.0'



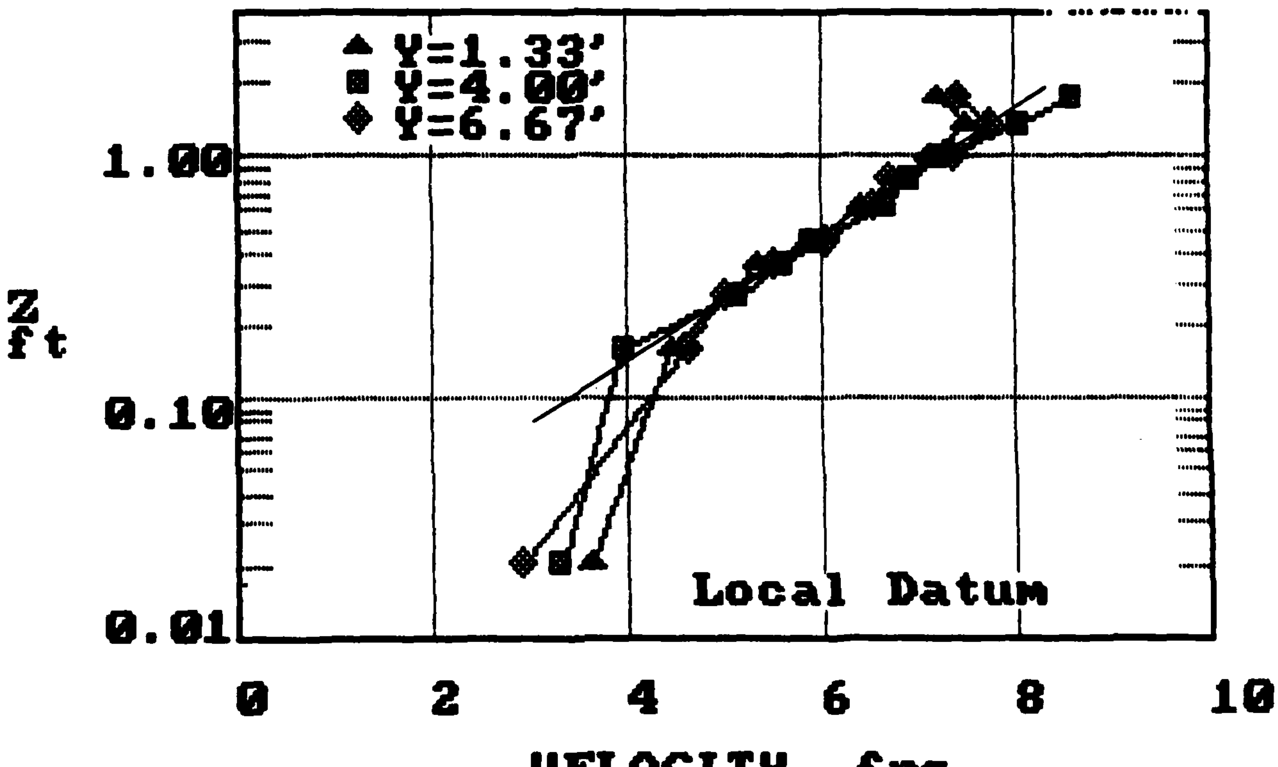
RUN # 67 , Q= 50 cfs, Y=4.0' LD



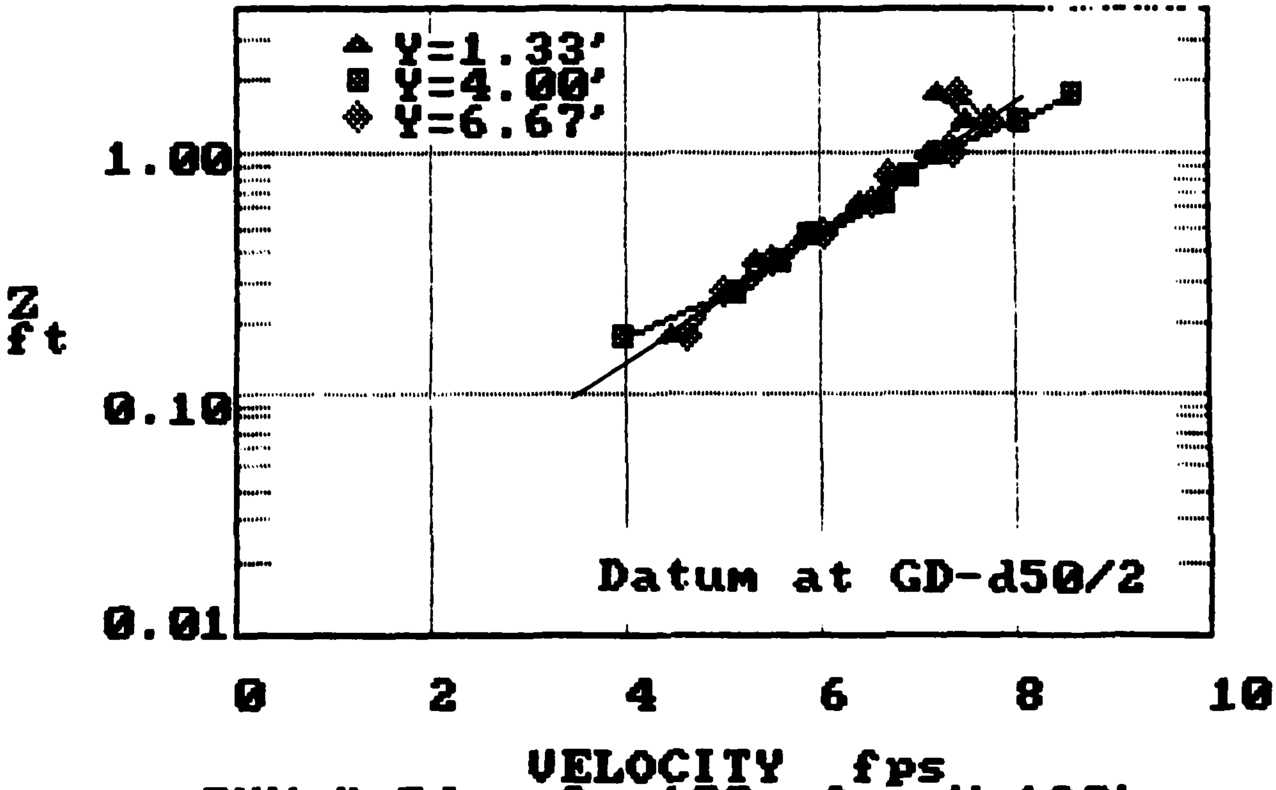
RUN # 74 , Q= 100 cfs, Y=4.0'



RUN # 74 , Q= 100 cfs, X=130'



RUN # 74 , Q= 100 cfs, X=130'



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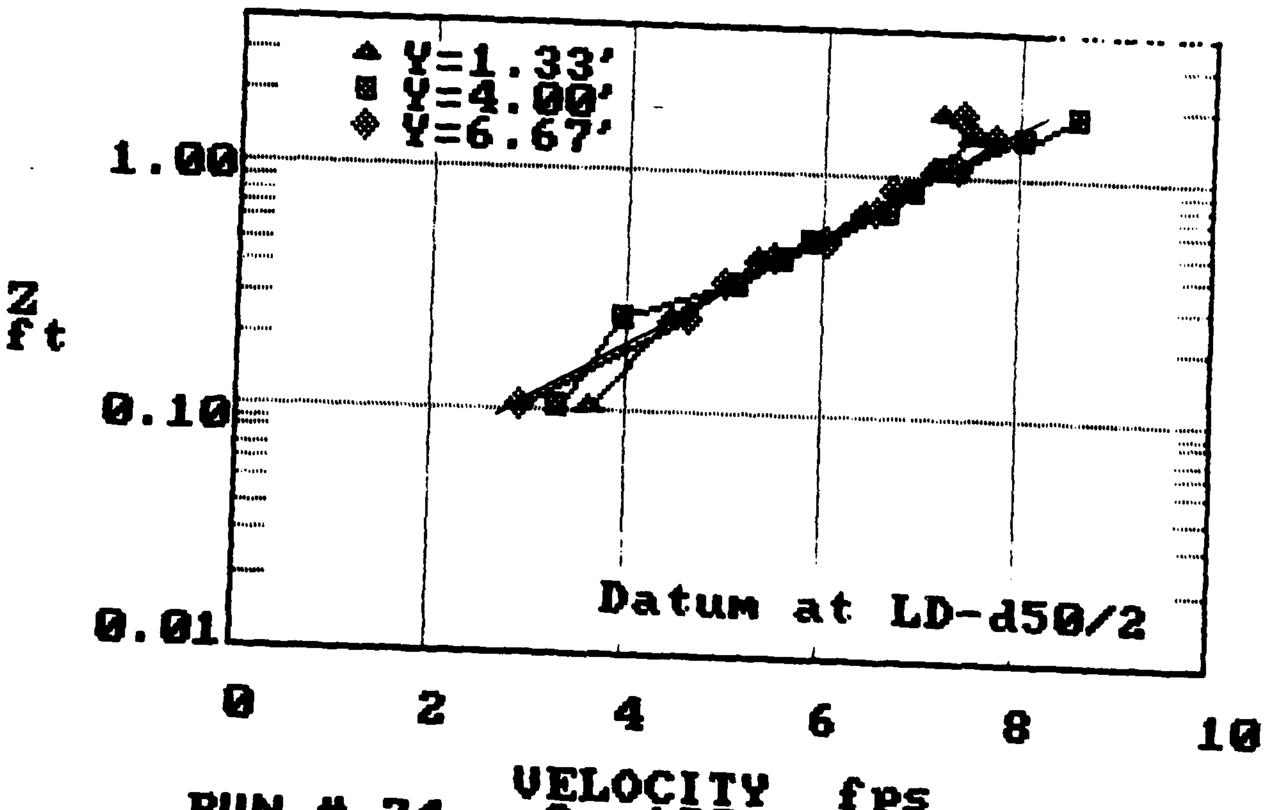
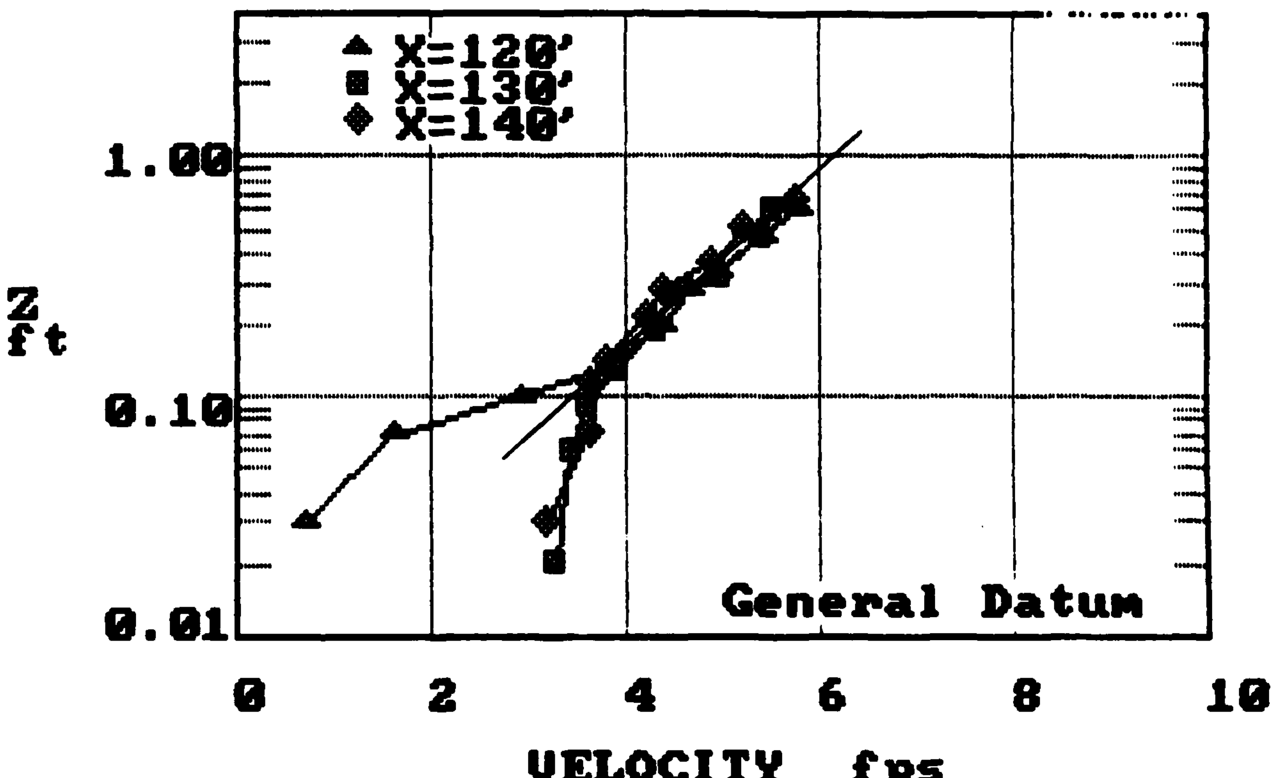
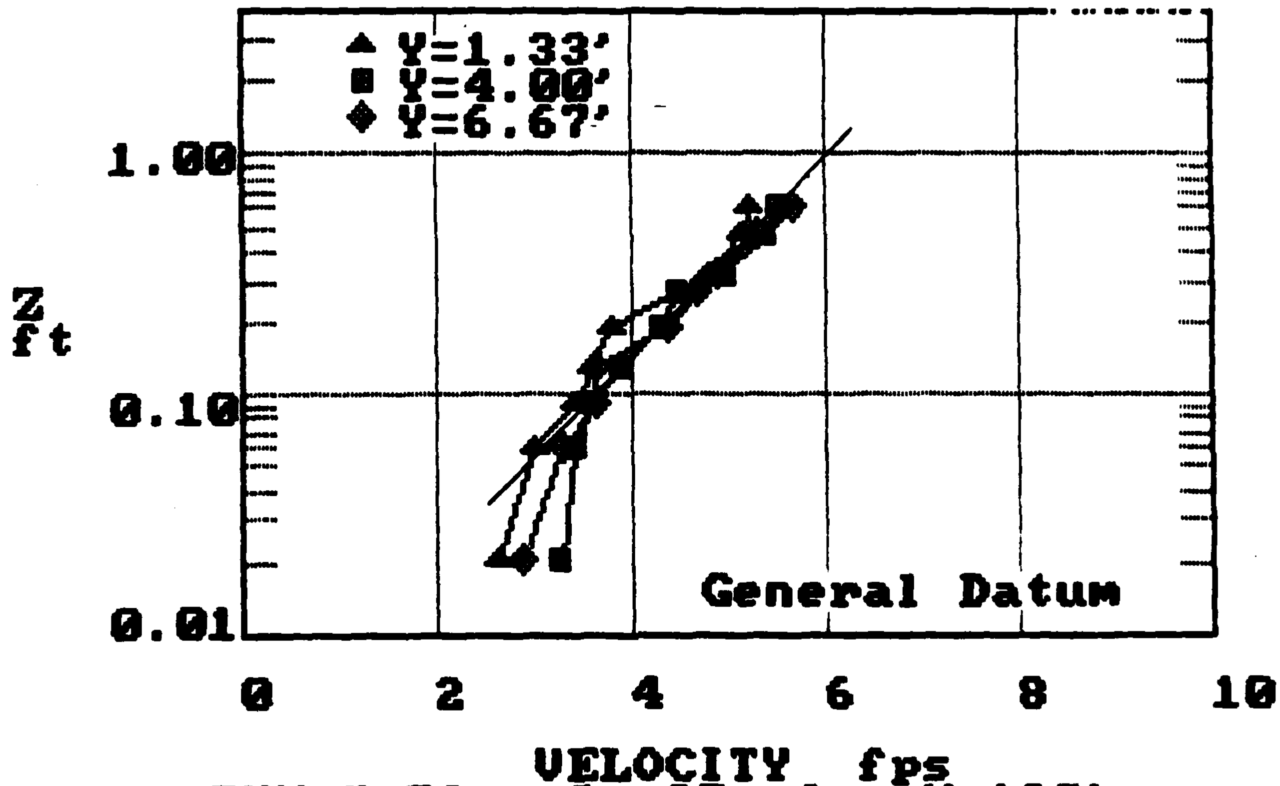


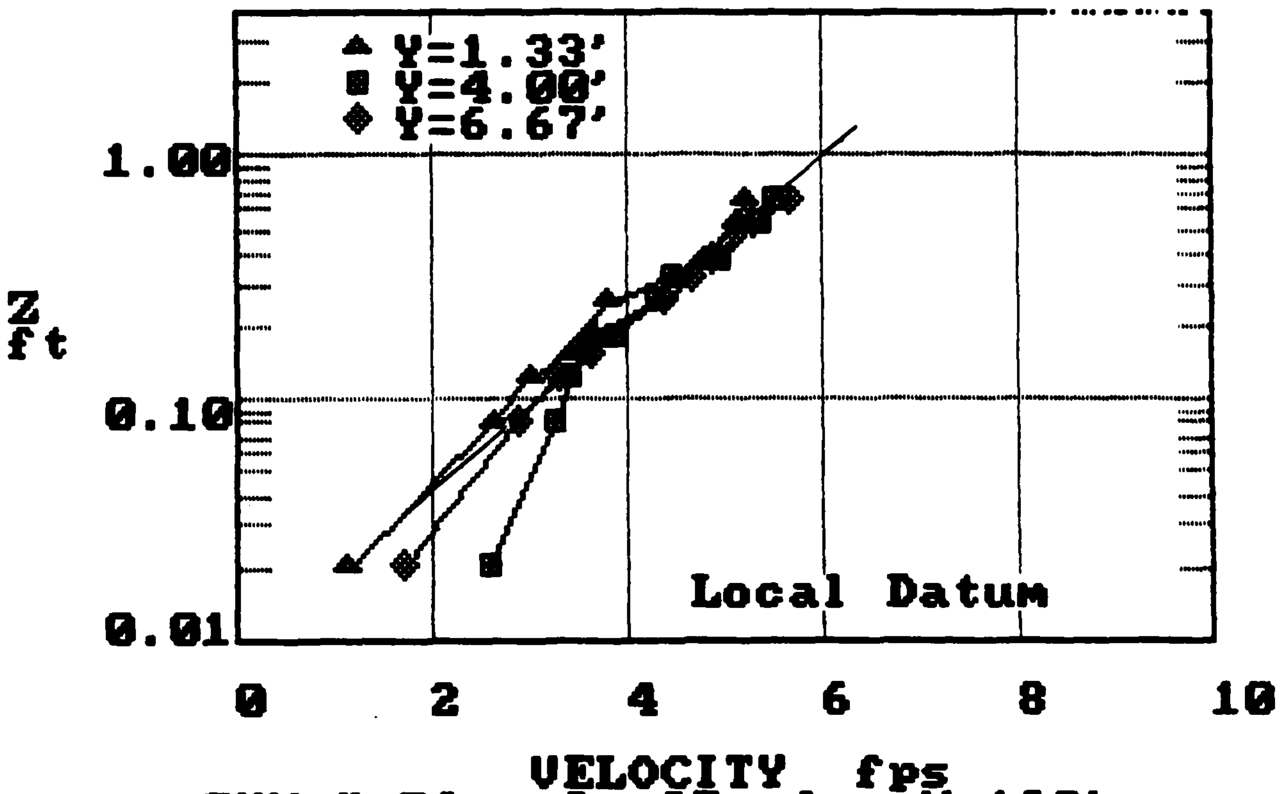
RUN # 74 , Q= 100 cfs, X=130' LD



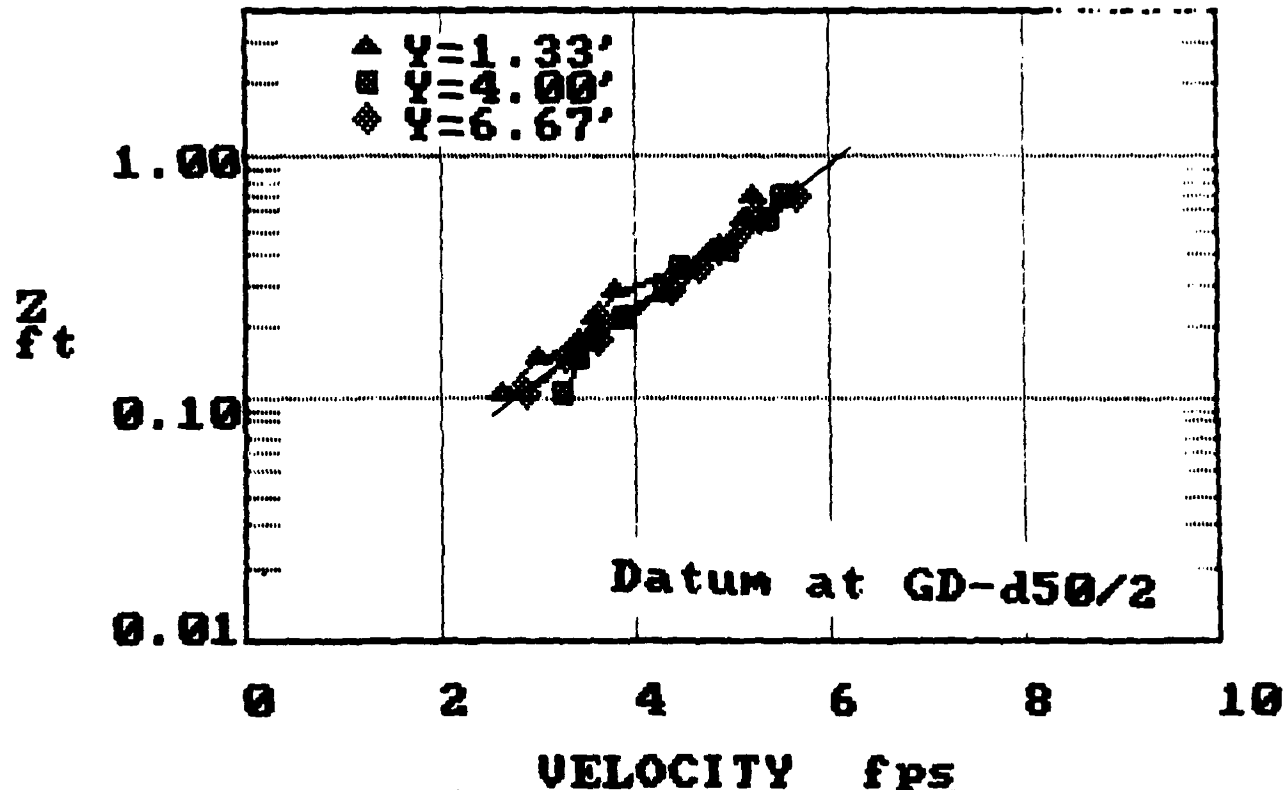
RUN # 76 , Q= 25 cfs, Y=4.0'



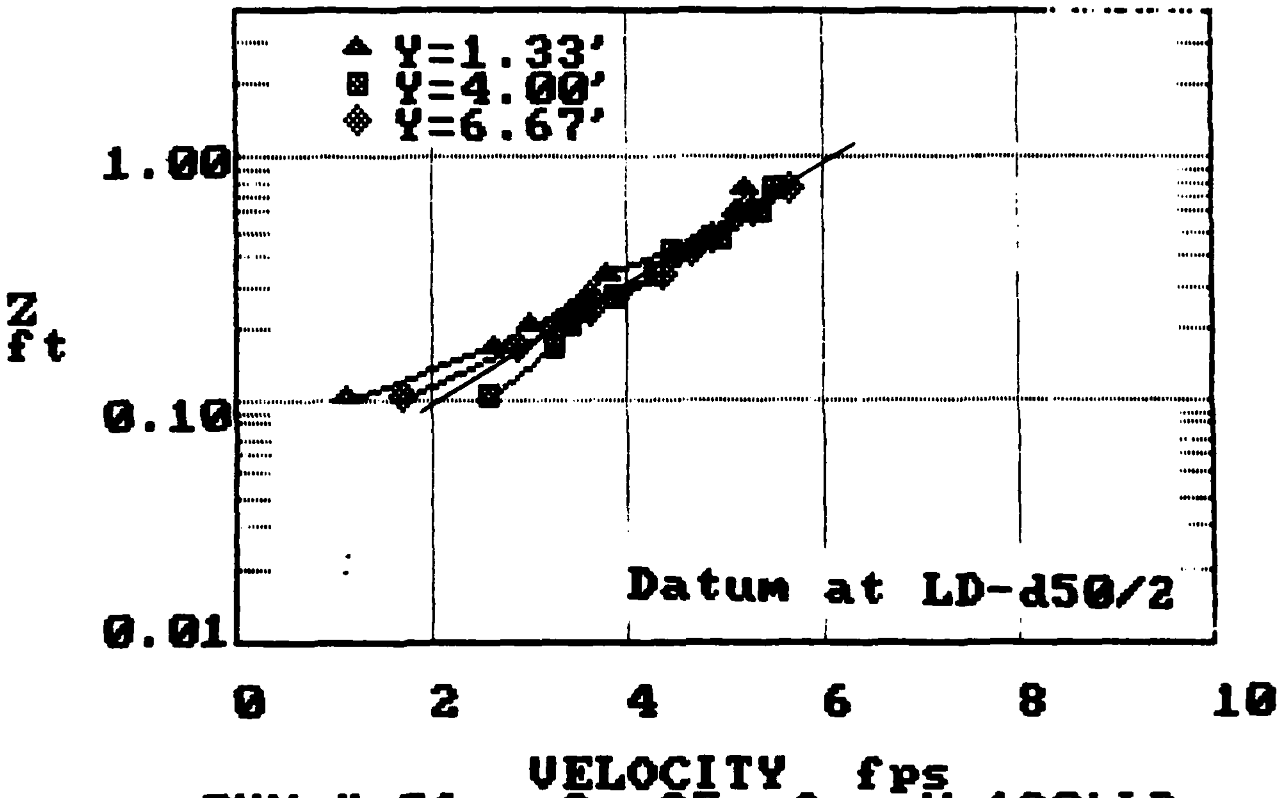
RUN # 76 , Q= 25 cfs, X=130'



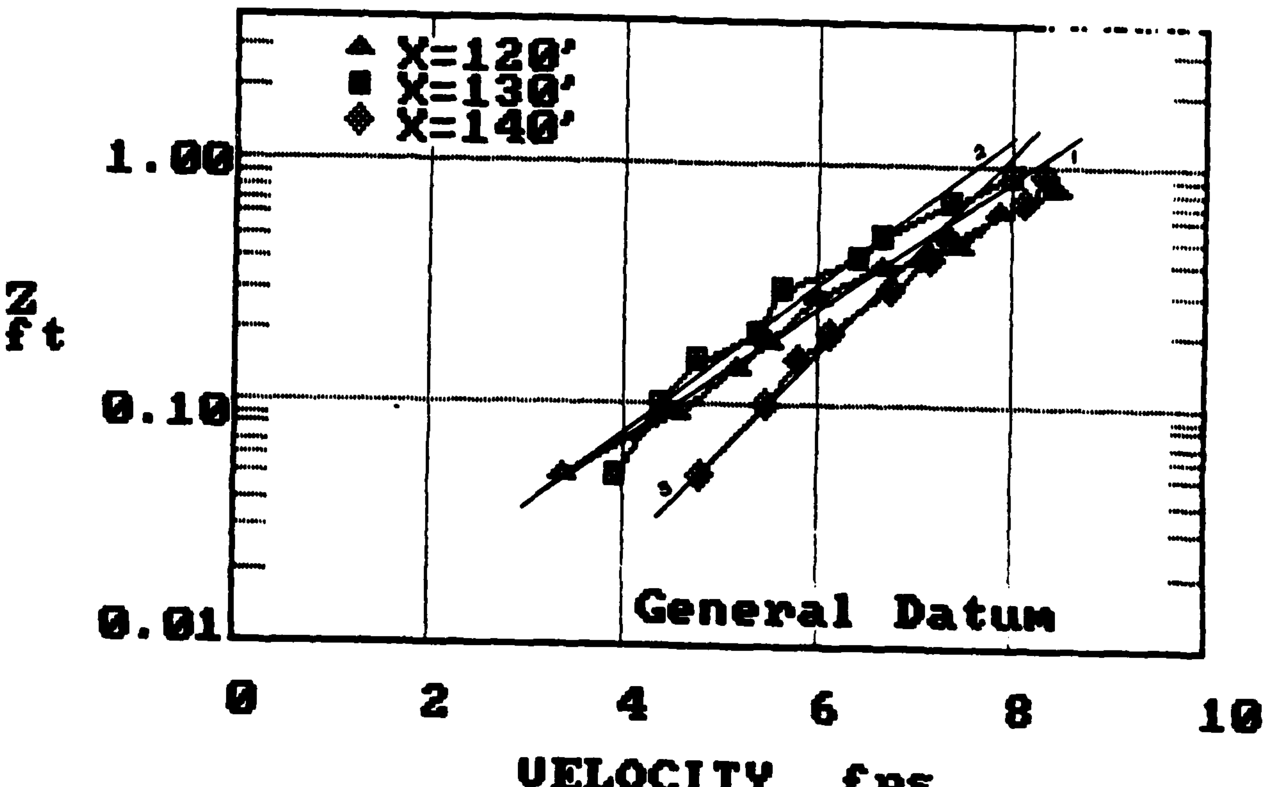
RUN # 76 , Q= 25 cfs, X=130'



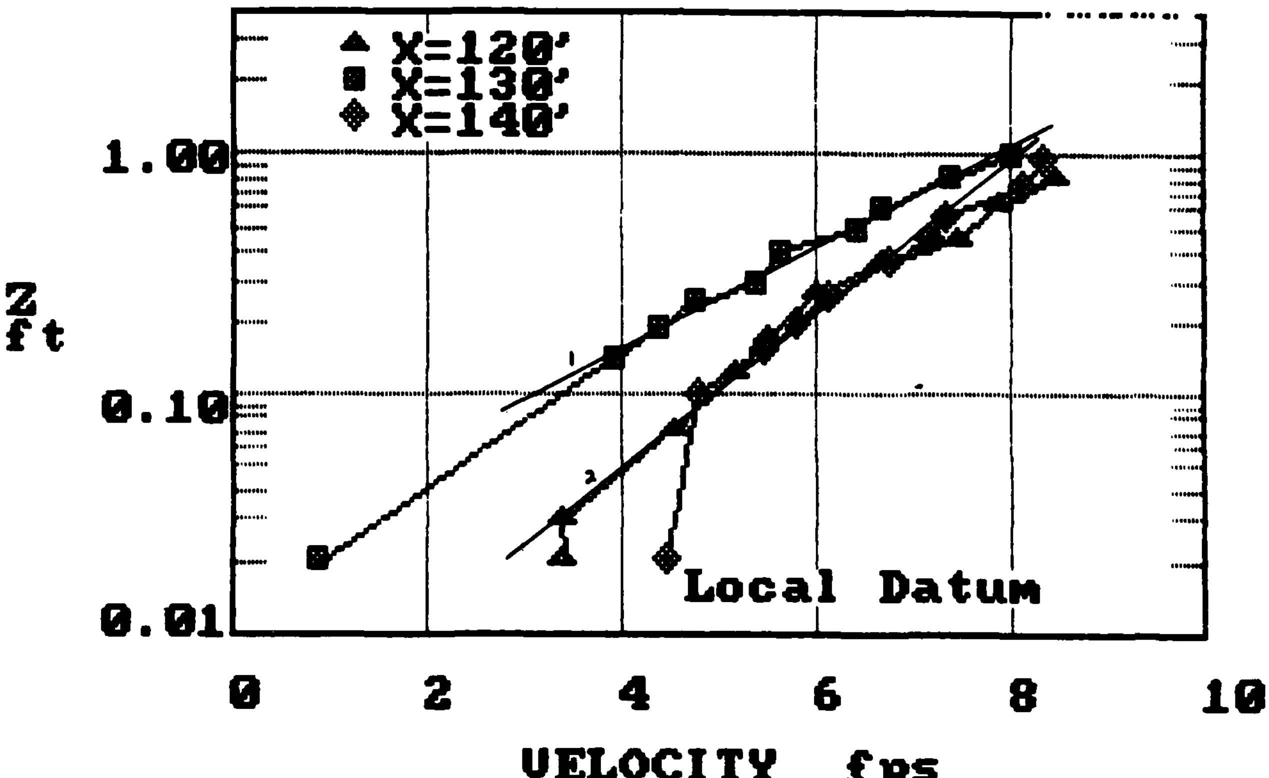
RUN # 76 , Q= 25 cfs, X=130'



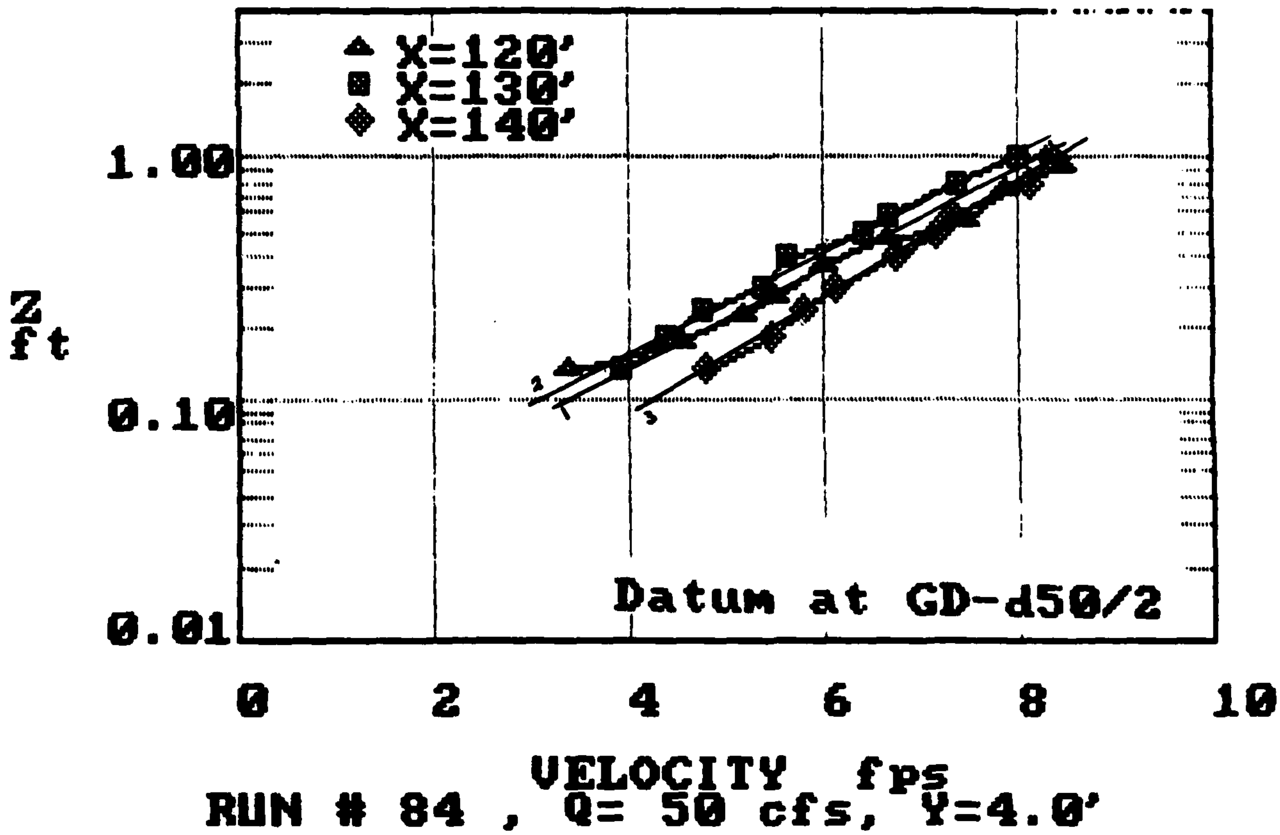
RUN # 76 , Q= 25 cfs, X=130' LD

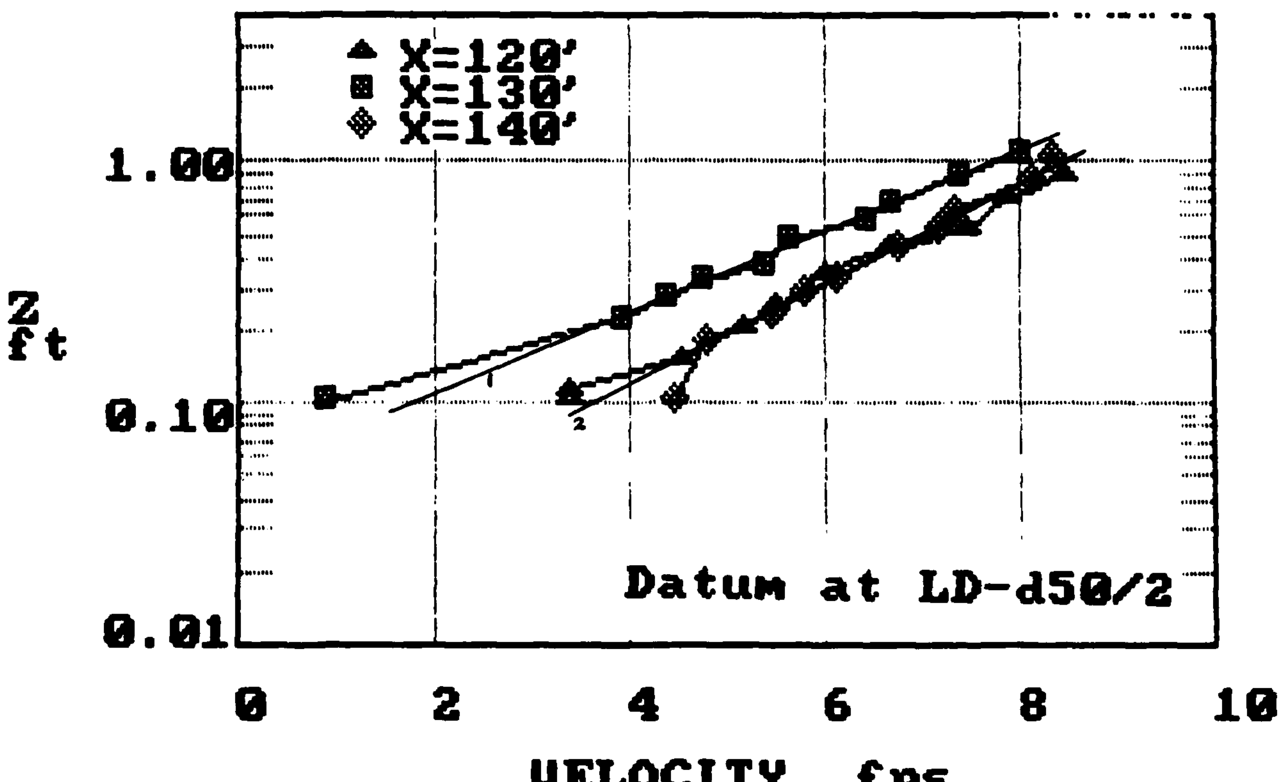


RUN # 84 , Q= 50 cfs, Y=4.0'

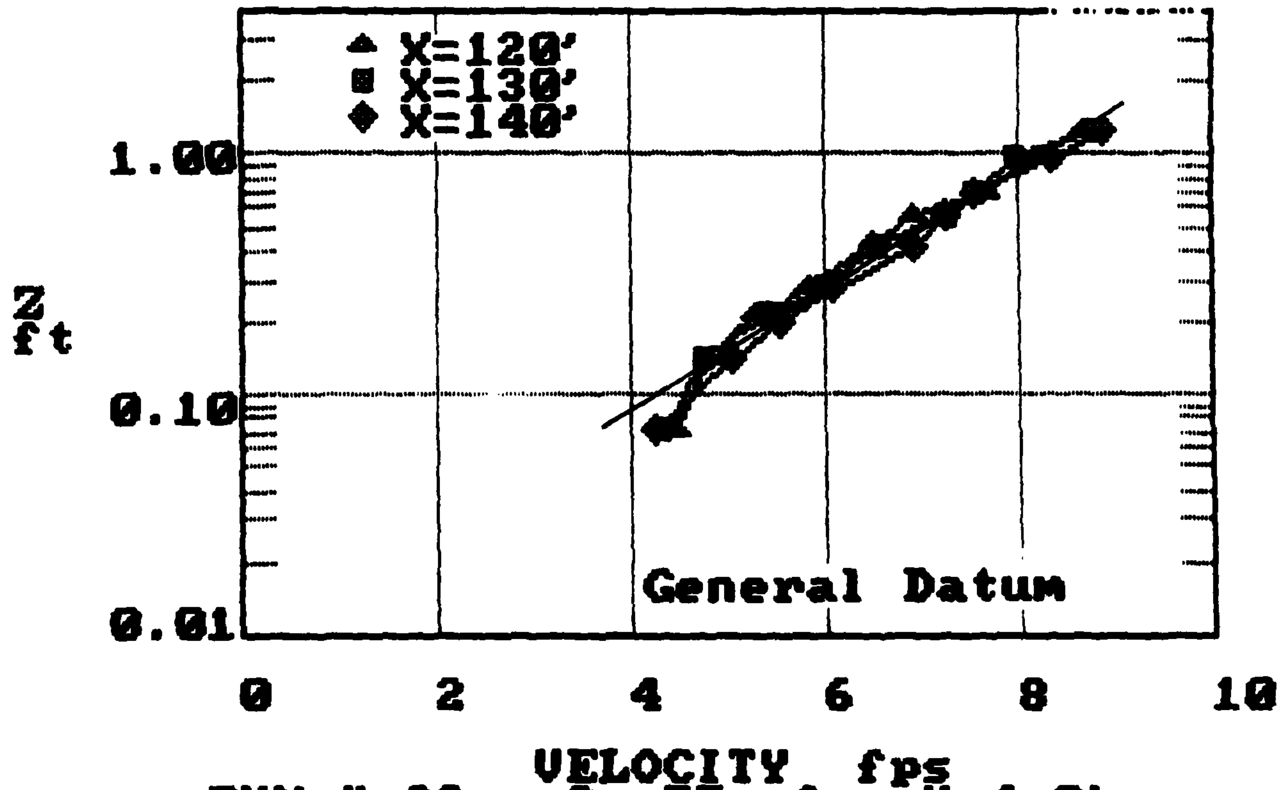


RUN # 84 , Q= 50 cfs, Y=4.0'

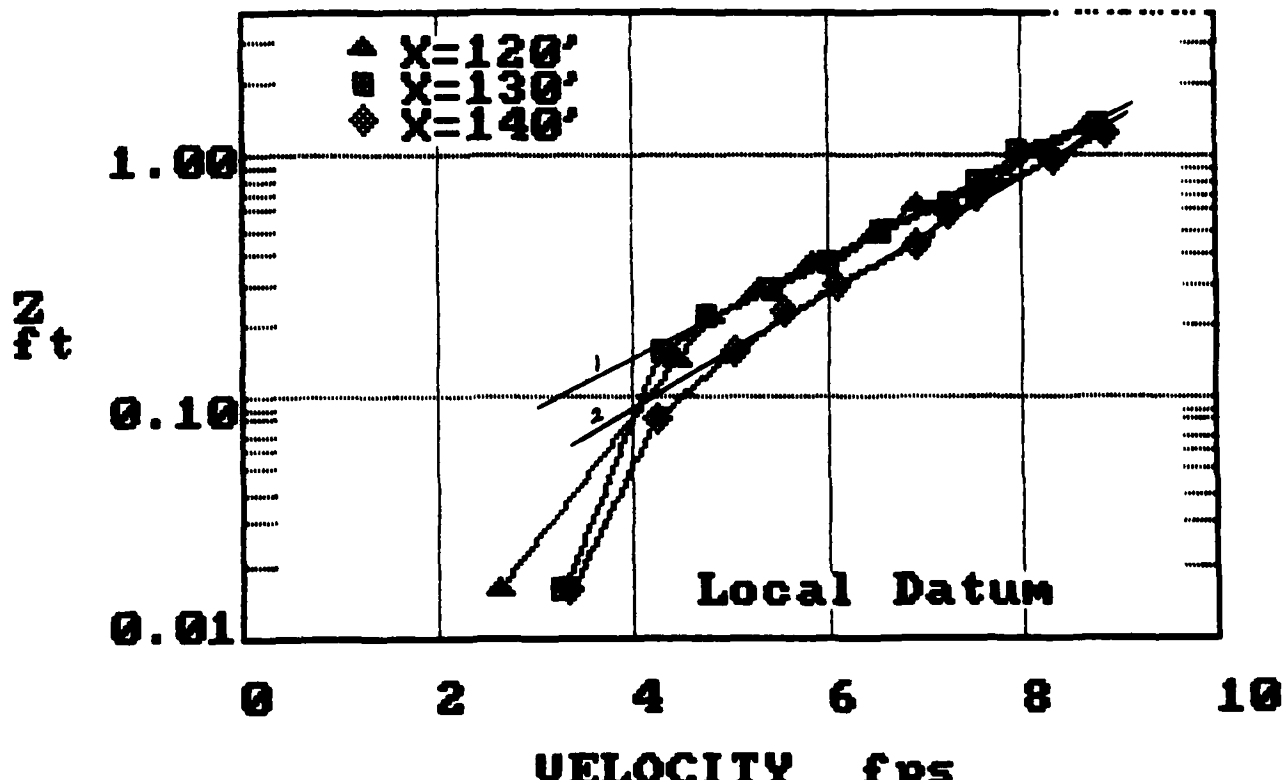

X=120'
X=130'
X=140'
1.00
0.10
0.01
Z
ft
Datum at GD-d50/2
0
2
4
6
8
10
VELOCITY fps
RUN # 84 , Q= 50 cfs, Y=4.0'



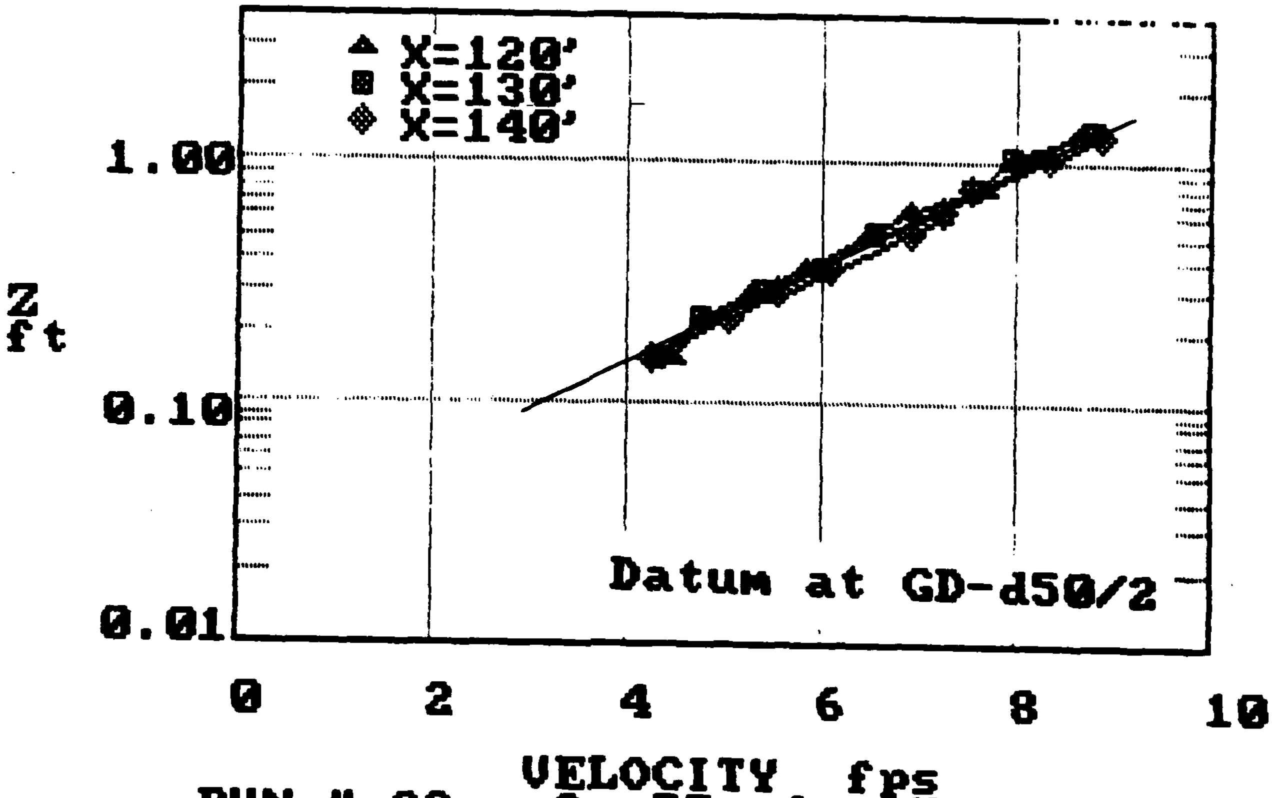
RUN # 84 , Q= 50 cfs, Y=4.0' LD



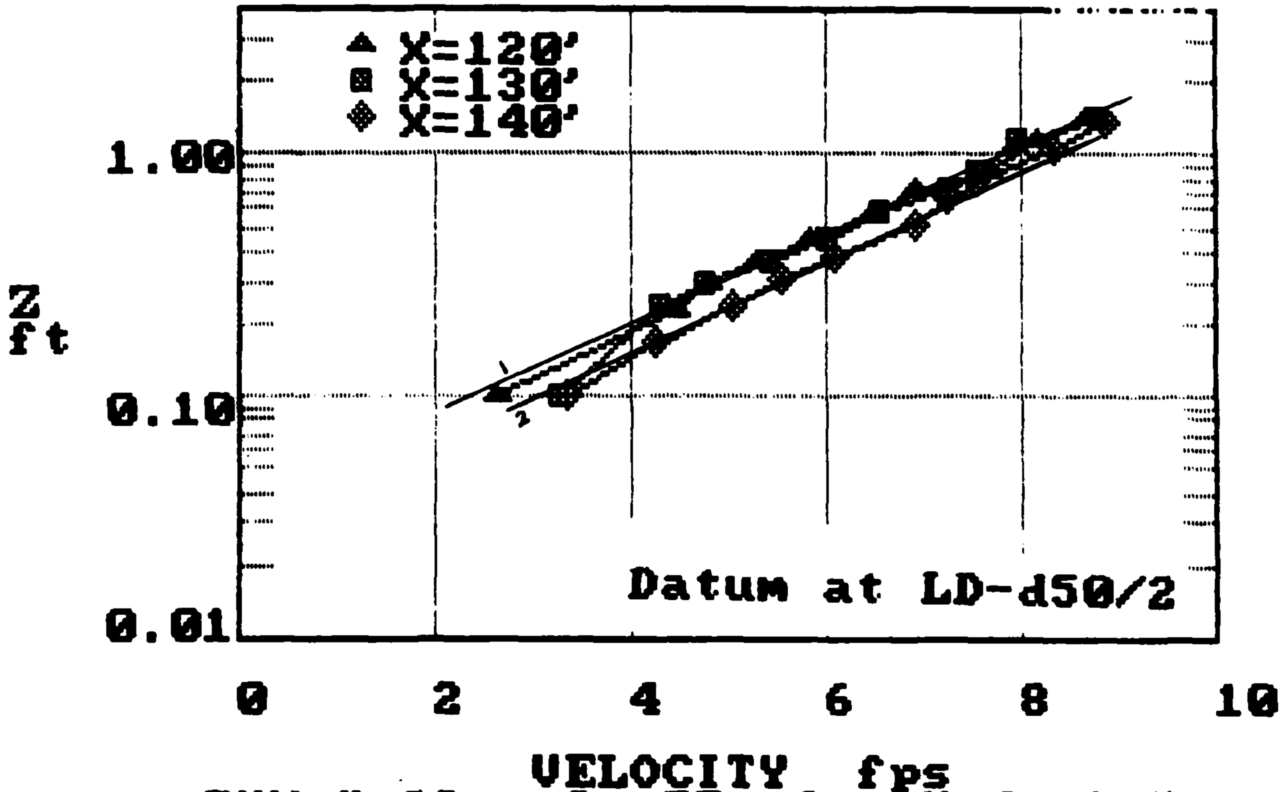
RUN # 88 , Q= 75 cfs, Y=4.0'



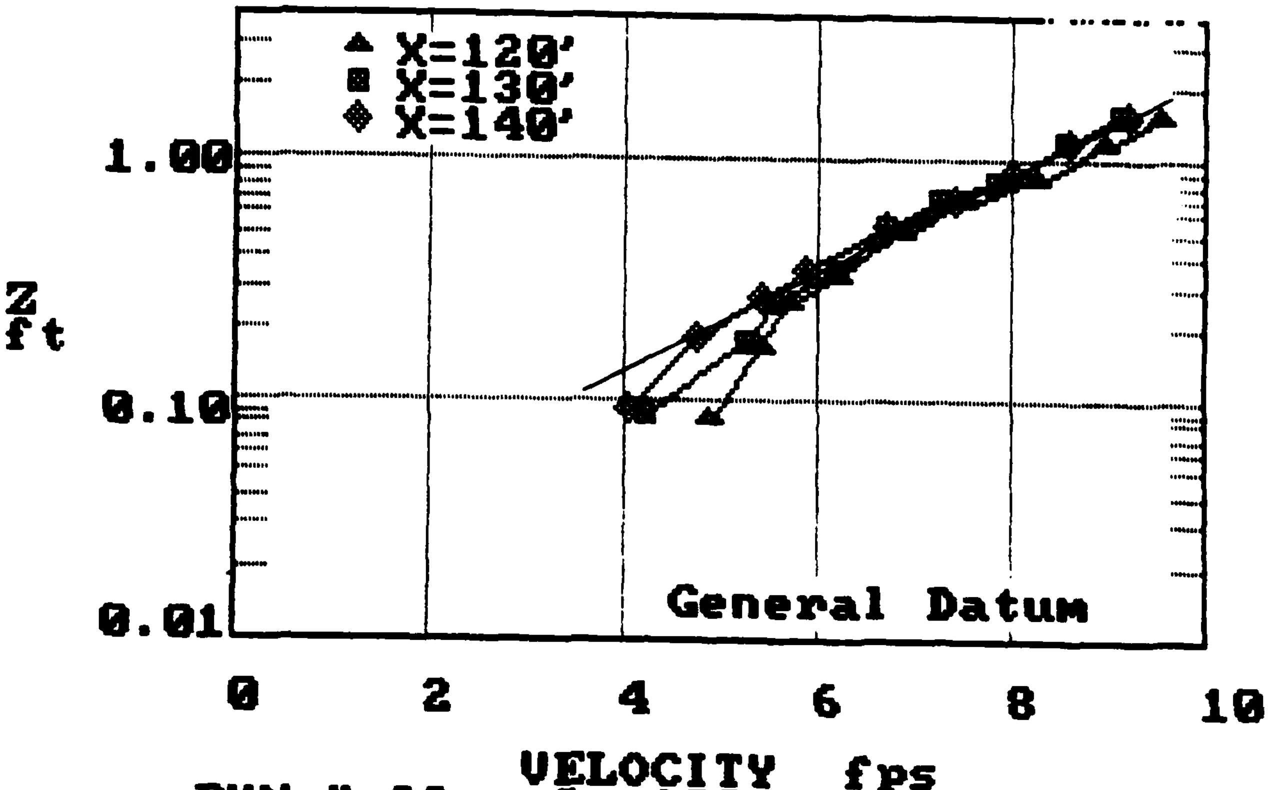
RUN # 88 , Q= 75 cfs, Y=4.0'



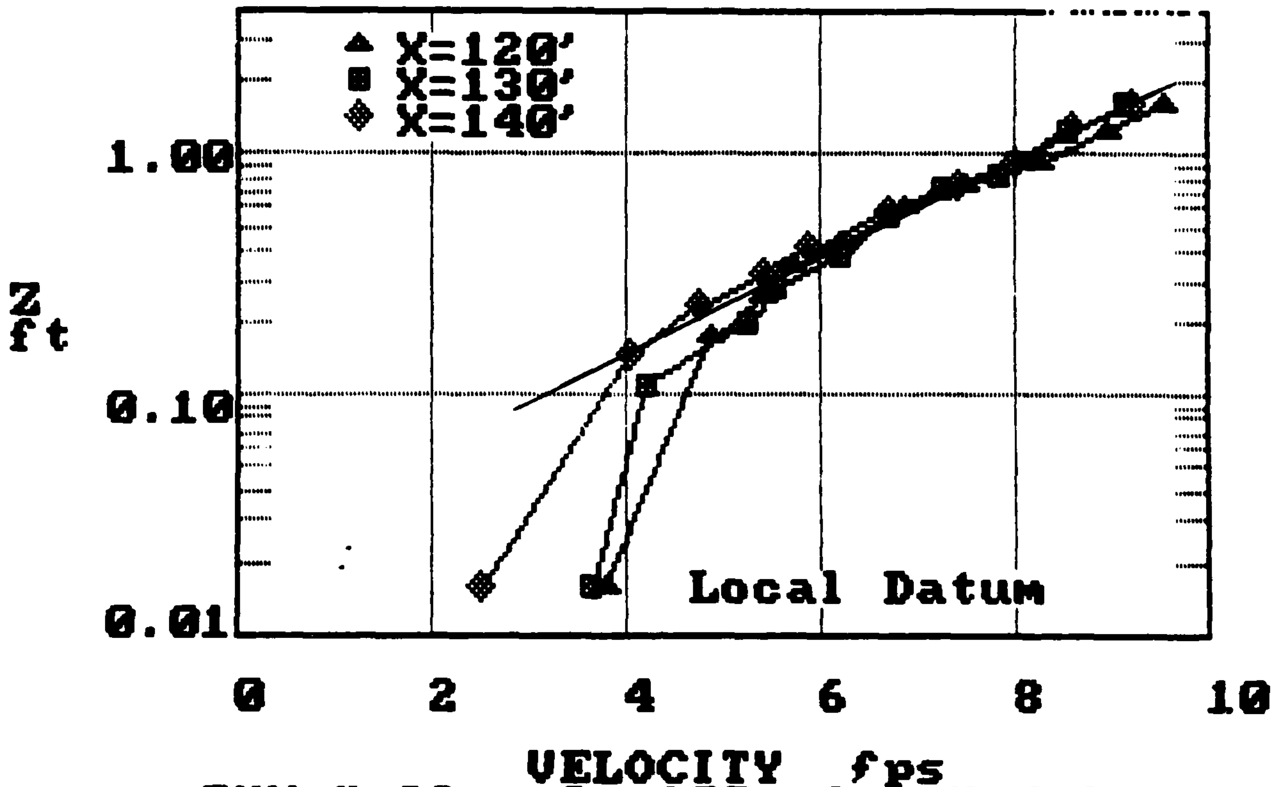
RUN # 88 , Q= 75 cfs, Y=4.0'



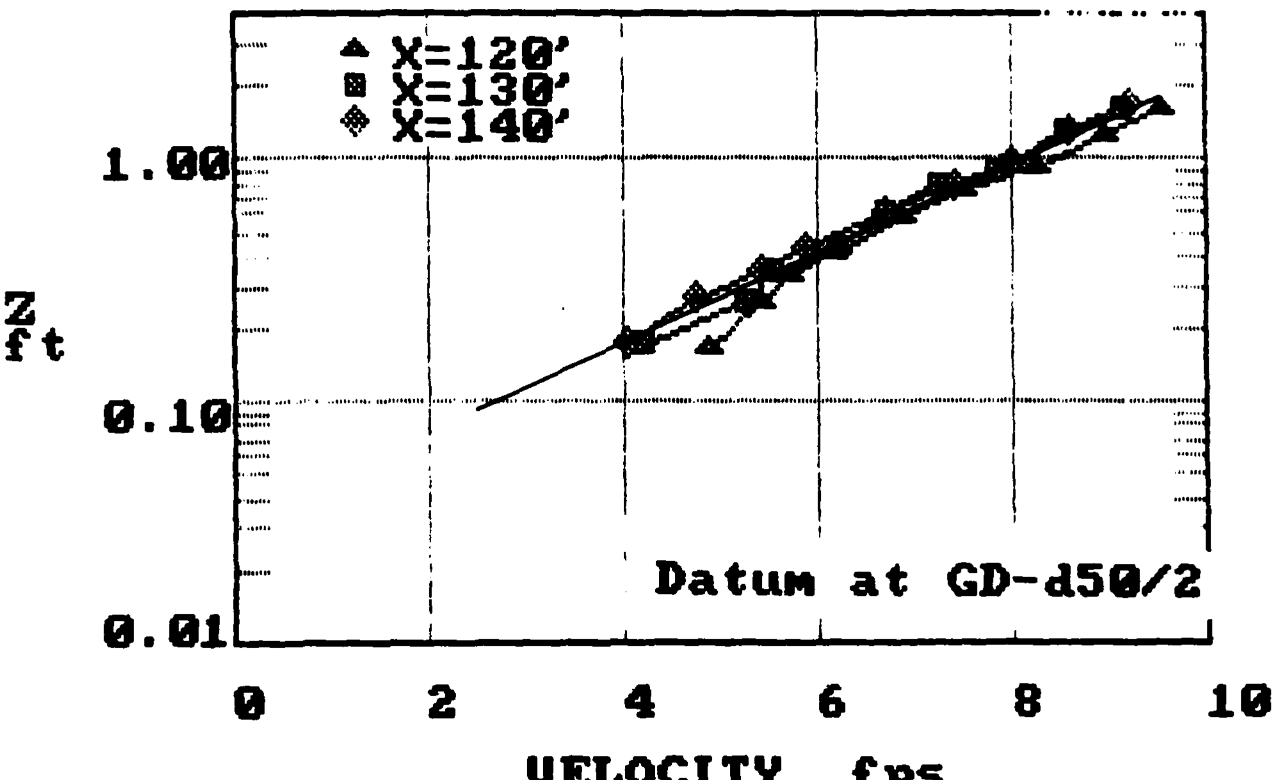
RUN # 88 , Q= 75 cfs, Y=4.0' LD



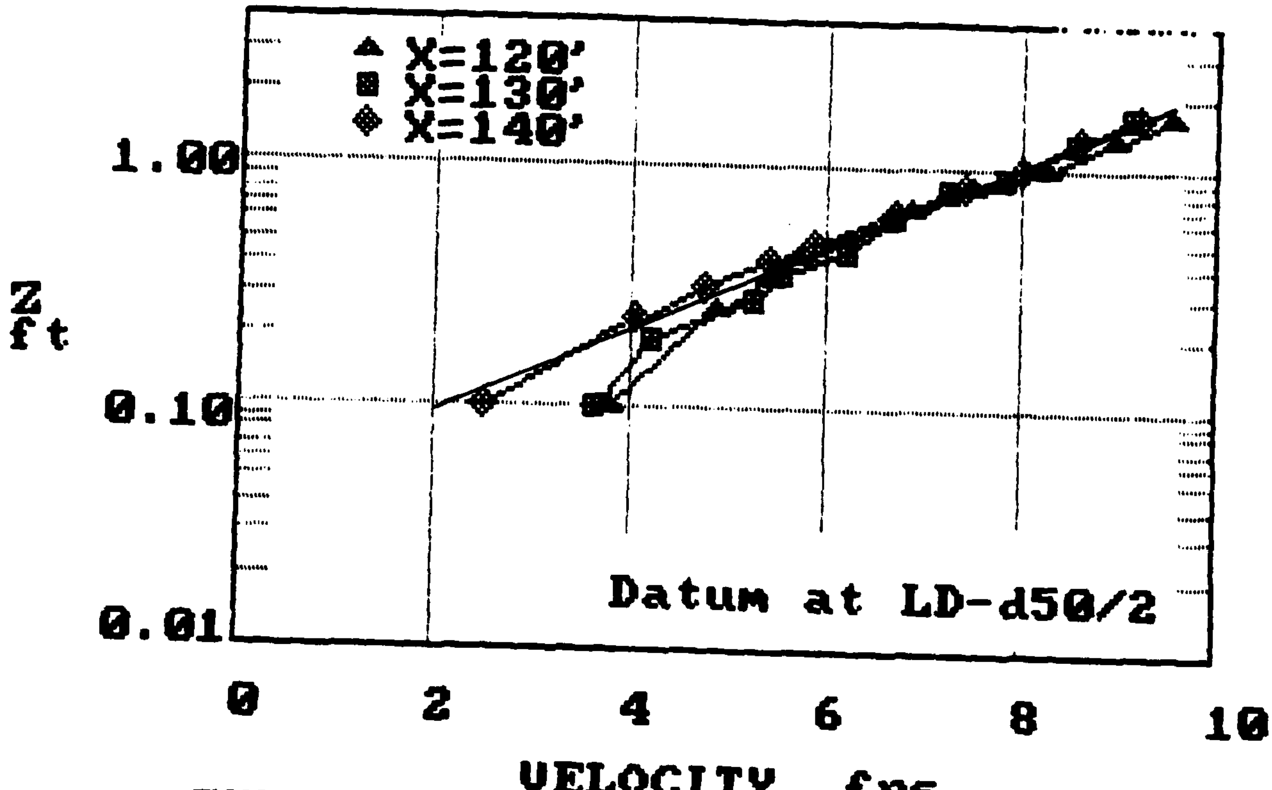
RUN # 93 , Q= 100 cfs, Y=4.0'



RUN # 93 , Q= 100 cfs, Y=4.0'



RUN # 93 , Q= 100 cfs, Y=4.0'



RUN # 93 , Q= 100 cfs, Y=4.0' LD

RIPRAP STABILITY IN SIDE SLOPED CHANNELS

Prepared for

U. S. Army Corps of Engineers
Waterways Experimental Station
Vicksburg, Mississippi

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March, 1987

CHAPTER 1

INTRODUCTION

This study is a continuation of the work to determine the point of incipient failure and other hydraulic characteristics of riprap for providing design criteria of stable riprap in flood control channels. The study was initiated in 1981 at Colorado State University (CSU), by and in cooperation with the U.S. Army Corps of Engineers, Waterways Experiment Station (WES), Vicksburg, Mississippi. The previous riprap studies were conducted on flat beds and results were presented in three reports. The first report, entitled, "Stability Tests of Riprap in Flood Control Channels," was prepared by A. A. Fiuzat, Y. H. Chen, and D. B. Simons, in October, 1982. The second report was entitled "Supplemental Stability Tests of Riprap in Flood Control Channels" and was prepared by A. A. Fiuzat and E. V. Richardson in December, 1983. The third report, entitled "1985 Riprap Tests in Flood Control Channels" was prepared by J. F. Ruff, A. Shaikh, S. R. Abt, and E. V. Richardson in August, 1985.

This 1987 report presents the results of riprap stability testing in a channel with side slope of 2H:1V. The report presents the results of three series of tests involving two riprap sizes. The riprap have a median diameter of d_{50} = 1 in. and d_{50} = 0.5 in. The d_{50} = 1 in. riprap was tested with two bed and side-slope thicknesses of 2 in. and 1.5 in. The d_{50} = 0.5 in. riprap was tested only with a thickness of 0.75 in.

CHAPTER 2

EXPERIMENTAL PROGRAM

An experimental investigation was conducted to determine the failure and incipient failure conditions of two riprap sizes in a side-sloped channel under a range of discharges. The exposure of the filter blanket underneath the riprap was the failure criteria. The run with the next lower flume slope prior to the failure run was regarded as the "incipient failure" run. The following sections describe the apparatus, materials, and procedures used in this study.

2.1 Experimental Setup

The riprap tests were conducted in a tilting flume 200 ft long, 8 ft wide, and 4 ft deep. The flume is constructed primarily of aluminum sides and bottom. A portion of the left[1] side of the flume is made from acrylic plastic to allow observation of a part of the section under study. The channel side-slope was constructed on the right side of the flume from plywood and dimension lumber. A schematic diagram of the flume with channel side slope is shown in Figure 2.1.

The 90 ft long channel with a 2H:1V side-slope was constructed from Station 80 to Station 170. The channel is divided in three sections: a 50 ft long test section, a 20 ft long entrance section, and a 20 ft long exit section as shown in Figure 2.1. A 20 ft long transition connects the vertical wall of the flume to the channel side-slope from Station 60 to Station 80.

[1]Left and right refer to the observer's left and right side as the observer looks downstream.

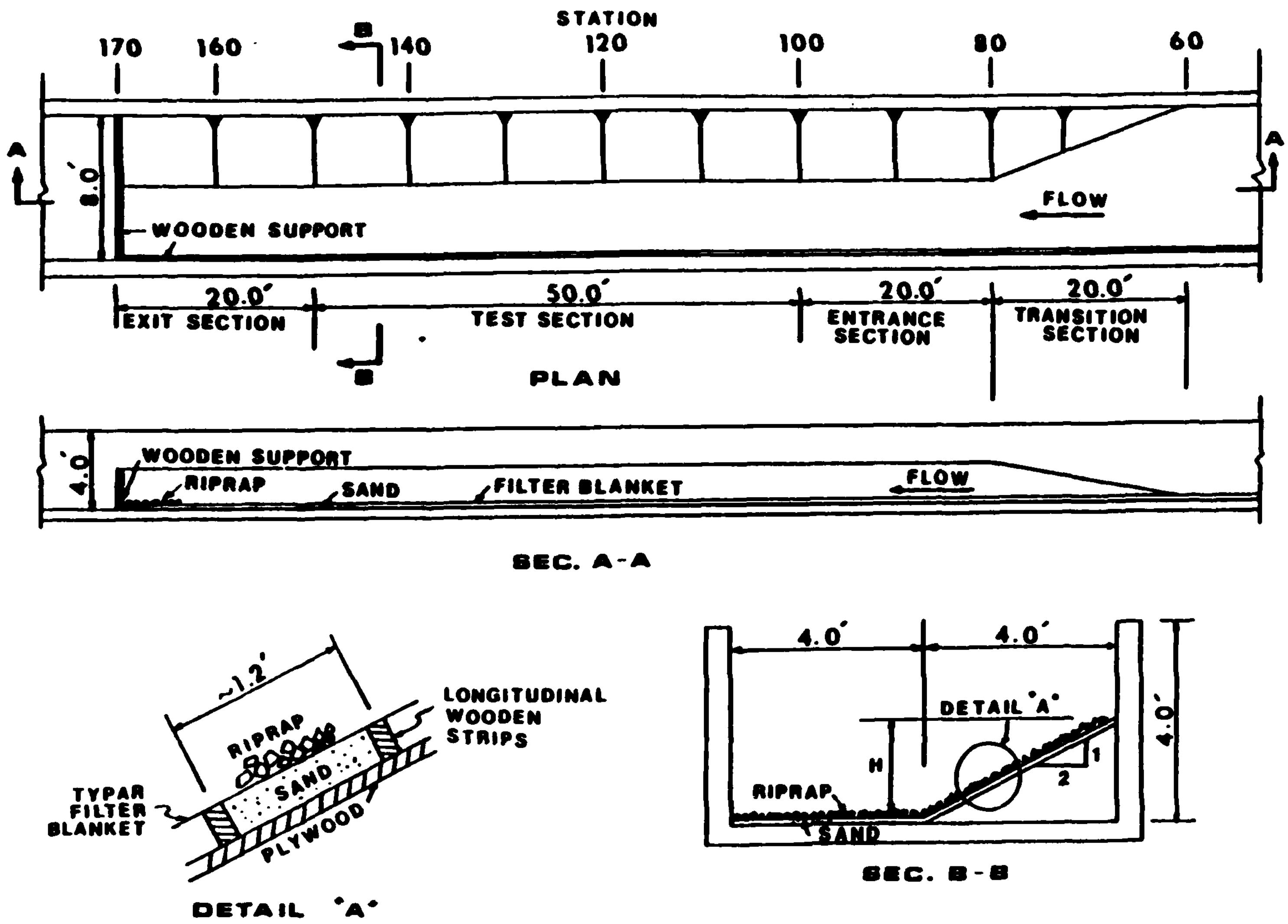

Figure 2.1 Schematic Drawing of the Channel

Photographs of the channel during construction and after placing the riprap are shown in

Figure 2.2. A photograph of the flume during operation is shown in Figure 2.3. Figure 2.4 shows the photograph of the d_{50} = 1 in. riprap after a test. The dark objects in the photograph are the painted rocks.

The channel was constructed and the riprap placed in the following method:

1. The channel side-slope was constructed with plywood and dimensional lumber.
2. Longitudinal wooden strips 2 in. high and 1 in. thick were attached to the side-slope at approximately 1.2 ft intervals as shown in Detail "A" in Figure 2.1. These strips were used as the support for the sand which later was placed on the side-slope. Wooden supports also were placed at the downstream end of the channel and at the left corner of the flat bed.
3. A 2 in. thick layer of plaster sand was placed on the side and bottom of the channel and compacted.
4. A layer of Typar filter blanket was placed on the sand surface and stapled to the supports on the side-slope and flat bed.
5. Riprap was placed by hand in the channel to the desired thickness using a template to achieve a uniform rock thickness throughout the channel.
6. A wooden support template was placed at the downstream end of the channel flush with the riprap surface to prevent the riprap from sloughing off the end of the section as shown in Figure 2.1.
7. The riprap in the entrance and transition section, Station 70 to 95, was covered with a wire mesh (chicken wire) to prevent riprap failure that could result from entrance flow conditions.

(a) During Construction Showing the Filter Blanket

(b) After Placing the Riprap on the Top of Filter Blanket

Figure 2.2 Photographs of the Channel

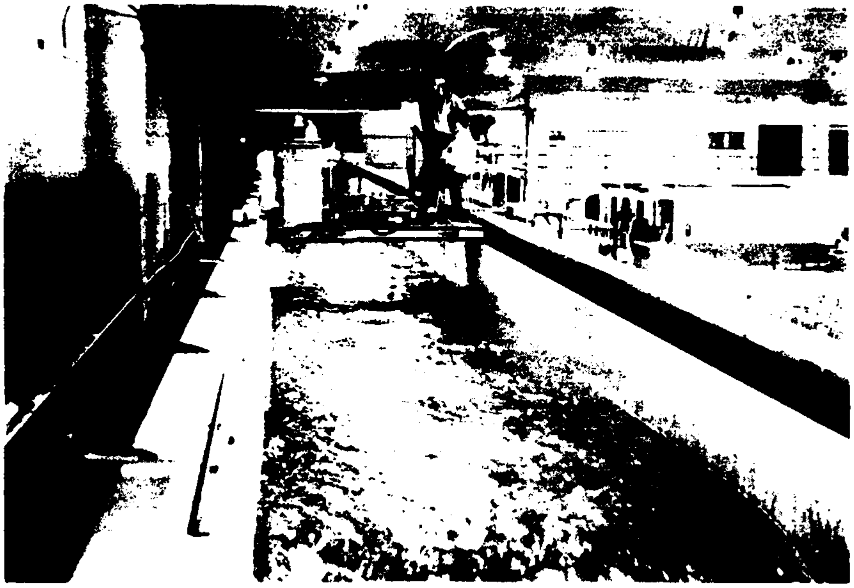

Fig. 2.3 Photograph of the Flume During Operation

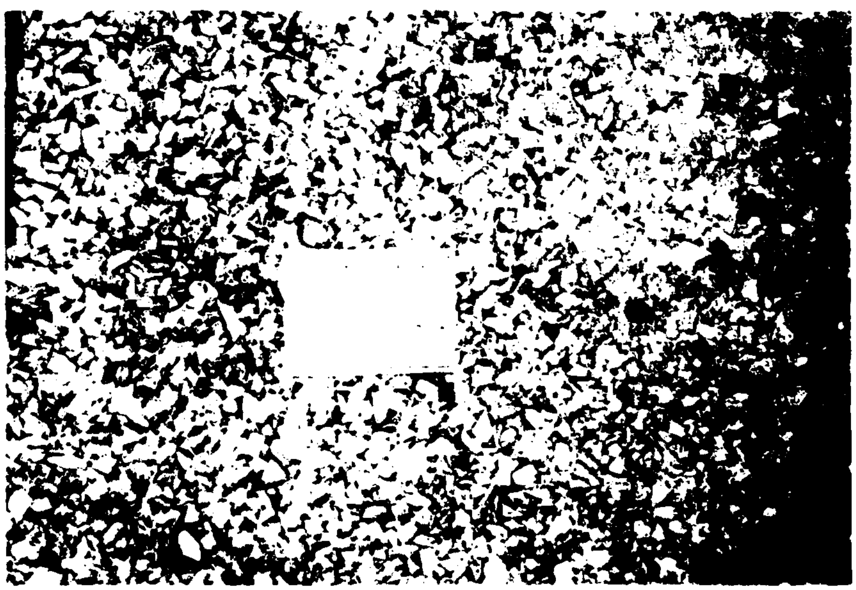

Fig. 2.4 Photograph of d_{50}= 1 in. Riprap After a Test.
The dark objects in the photograph are painted rocks.

2.2 Test Variables

Tests are conducted at various slopes for a specified discharge to determine the incipient failure conditions of the riprap material. The experimental variables are riprap median size (d_{50}), riprap thickness, and discharge as presented in Table 2.1. A summary of the tests, including bed and water surface slope, water temperature, area washed, and test duration are presented in Chapter 3.

TABLE 2.1 Test Variables

Test Series #	Median Size (in)	Riprap Thickness (in)	Discharge cfs	Run #
1	1	2	15, 20, 30, 40, 50	1 - 35
2	1	1.5	15, 20, 30, 40, 50	36 - 50
3	0.5	0.75	15, 20, 30, 35, 40	1 - 23

2.3 Material

Crushed limestone was used as the riprap material. The specific gravity of both the d_{50} = 1 in. rock and d_{50} = 0.5 in. rock is 2.68. The gradation of the riprap material tested is shown in Figure 2.5 and is compared with the ETL 1110 - 2 - 120 gradation recommended by the Corps of Engineers. To determine the riprap gradation, samples of the in-place riprap at three locations along the channel were collected and a sieve analysis was conducted for each individual sample. the results were averaged to obtain the riprap gradation for each riprap size. for d_{50} = 1 in. riprap with 1.5 in. thickness, only one sample was analyzed. The gradation

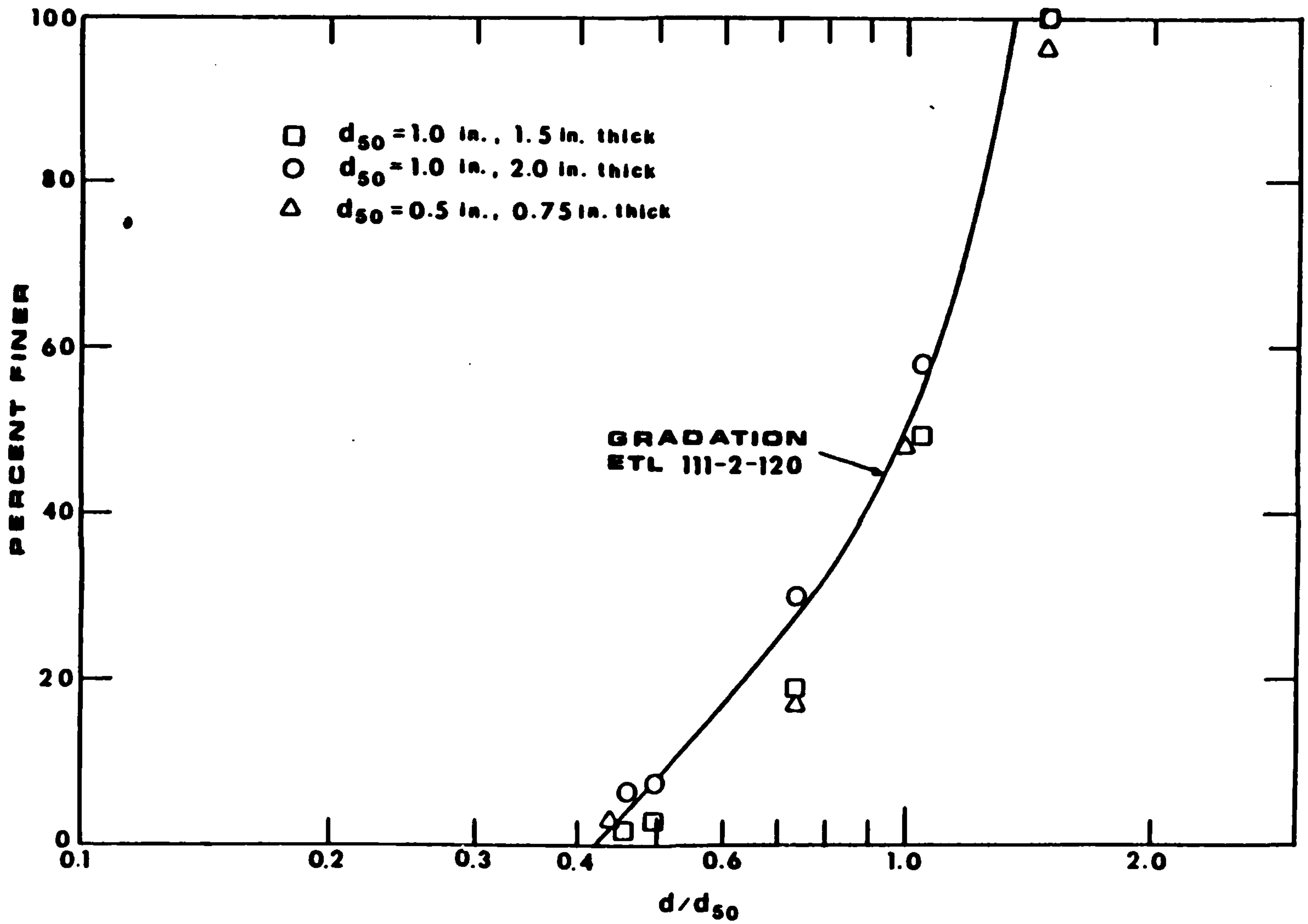

Figure 2.5 Gradation of In-place Riprap

analyses were performed before beginning a test series.

The riprap material meets the shape criteria of the Army Corps of Engineers. These criteria are found in C.O.E. Report EM 1110-2-1601, 1970 and are summarized as:

1. The stone shall be predominantly angular in shape.
2. No more than 25% of the stones reasonably well distributed throughout the gradation shall have length more than 2.5 times the breadth or thickness.
3. No stone shall have a length exceeding 3.0 times its breadth or thickness.

2.4 Testing Procedure

The tests were conducted systematically to determine when incipient failure of the riprap occurred. For each riprap size, thickness, and discharge presented in Table 2.1 the testing procedure was as follows:

1. A "failure slope" for a given discharge is estimated from the results of previous riprap studies.
2. The flume is set at a slope slightly less than the estimated failure slope.
3. The desired discharge is routed through the test channel starting with a larger water depth than the uniform depth for the selected discharge and slope.
4. The water depth is reduced in the test section to the uniform flow depth by gradually opening the tailwater control gate. Trials are made to set the water surface slope as close as possible to the bed slope. It was not possible to set the water surface slope equal to the bed slope because of small waves on the water surface. The tailwater depth is set to prevent failure of the riprap at the downstream end. The water depth in the channel is always less than or equal to the channel depth (H) shown in Sec. B-B of Figure 2.1.

5. Tests are conducted for 2 to 4 hours after establishing the flow as uniform as possible. Water surface elevations, water depths, velocity profiles, discharge, and water temperature are measured during each test. Tests are terminated at any time that riprap failure is observed.
6. If riprap failure is not observed during or after a test run, the flume slope is increased by a small increment and a new test is performed. The flume slopes and corresponding discharges that were tested are presented in Chapter 3. This procedure is continued until riprap failure is observed. If riprap fails in the first trial, the flume slope is decreased by a small increment and the test is repeated. This reduction in slope continues until no washed areas are observed and a stable condition exists. Before starting a new test, the riprap surface is reshaped to the original shape of the channel.
7. The washed areas when observed are measured and mapped at the end of a test run.

A series of tests were conducted to force the riprap failure to occur on the channel side-slope. During these tests the bed was stabilized using chicken wire to prevent movement of the riprap on the bed. Tests were conducted until failure of the riprap occurred on the side-slope of the channel.

Tests also were performed to observe the effect of time on channel riprap stability. The channel was subjected to flow for periods of 6 to 8 hours at flow and slope combinations considered to be stable during the 2 to 3 hour normal test periods.

2.5 Data Collection Program

The data collected include bed and water surface elevations, discharge, velocity profiles, water temperature, and the size and locations of areas washed free of riprap where the underlying filter blanket was exposed. The velocity data

were collected using pitot-static tubes. Velocity profile traverses were taken at several locations in the cross sections throughout the test section. Specific traverse locations are listed for each run in the Appendix. Bed and water surface elevations were established using a surveying level. The bed slope was determined directly from the elevations at the top of the flume wall. The wall top is parallel to the flume floor. Water surface slope was determined by measuring the water surface profile with a foot gage and then converting the gage reading to an elevation. Elevations of the foot gage at different locations were established by surveying with the level.

Two sizes of pitot-tubes, a 3/8 in. O.D. and a 1/4 in. O.D. pitot tubes, were used to collect the velocity data. The 3/8 in. pitot tube was connected to a water manometer and velocity heads were recorded directly from the manometer. The 1/4 in. pitot tube was connected to a pressure transducer , a transducer indicator, and a digital voltmeter. The 3/8 in. pitot tube was used in runs # 1 to 25 of the $d_{50} = 1$ in. riprap and the 1/4 in. pitot tube was used in all other tests.

Prior to the tests, strips of riprap were painted. The painted rocks were used to better observe the movement of the riprap and to detect failure or deformation of the riprap layer. Different colors were used. At the end of a test run, the locations of the painted rocks were observed and recorded.

CHAPTER 3

EXPERIMENTAL RESULTS

A summary of the tests conducted is presented in Tables 3.1 to 3.3 for the three series of tests. The summary Tables contain discharge, bed slope, water surface slope, average depth, average velocity, water temperature, area washed, test duration and percentage of colored rock moved. The failure runs and incipient failure conditions are indicated in the summary Tables. The areas washed on the bed and on the side-slope are presented in separate columns in the summary Tables. Velocity profile traverses are taken at several locations in the cross sections at Stations 120, 130, and 140. Specific locations for each run are given in the Appendix.

3.1 Remarks

The following are explanatory remarks for the tests summarized in Tables 3.1 to 3.3. These remarks will explain the selection of the point of incipient failure of the riprap material tested.

A. General Remarks

1. A run was considered to be a "failure run" when the underlying filter blanket was exposed in the test section during the run or the blanket was observed after the run during dewatering.
2. For a given discharge, the run with the next lower flume slope prior to the failure run was regarded as the "incipient failure run".
3. If a riprap failure appeared to be the result of local weakness of the riprap or local geometry imperfection of the channel, the riprap or the channel was reshaped and the test was repeated. An example is run #6 in Table 3.1 which had a washed area of 1.6 ft^2 at Station 101. This failure was believed to result from a localized thin layer

Table 3.1 Summary of the Tests Series #1; Riprap d50=1.0 in. and Thickness=2.0 in.

Discharge Q cfs	Run #	Bed Slope S	Water Surface Slope S	Average Depth D ft	Average Velocity V=Q/A fps	Water Temp. F	Area Washed sq. ft at bed	Area Washed sq. ft at side	Test Duration hrs.	Colored Rock Movement % by wt.
15	1	0.00813	0.00768	0.81	3.85	75			2.0	
15	2(R1)	0.00813	0.00745	0.82	3.80	74			2.25	
15	3	0.01003	0.00929	0.77	4.08	74			2.2	
15	f 4	0.01204	0.01127	0.73	4.34	72	4.2		3.3	
15	f 5	0.01300	0.01077	0.70	4.56	74	1.5		2.5	
15	$ 6	0.01237	0.00907	0.69	4.64	72	1.6		2.6	
15	$ 7(R6)	0.01237	0.00957	0.71	4.49	75			2.0	
20	12	0.00789	0.00491	0.96	4.20	72			2.75	14
20	13	0.00887	0.00804	0.89	4.60	72			2.4	15
20	$ 14	0.00993	0.00945	0.86	4.79	72			2.3	30
20	f 15	0.01087	0.01074	0.85	4.85	71	1.0		2.6	36
30	16	0.00700	0.00685	1.21	4.76	71			3.0	19
30	17	0.00797	0.00723	1.15	5.07	71			2.25	36
30	$ 18	0.00896	0.00677	1.13	5.18	71			2.6	49
30	f 19	0.00995	0.00796	1.09	5.41	71	25.9		1.2	62
40	20	0.00510	0.00515	1.53	4.73	70			2.2	29
40	21	0.00604	0.00595	1.47	4.98	70			2.75	33
40	$ 22	0.00701	0.00536	1.45	5.06	70			2.75	35
40	f 23	0.00800	0.00669	1.39	5.34	70		0.65	3.2	55
40	24(R23)	0.00800	0.00779	1.44	5.11	71			3.0	
40	f 25	0.00895	0.00729	1.35	5.54	71	7.9	6.3	2.3	51
40	L 26(R22)	0.00707	0.00560	1.55	4.65	71			8.0	47
40	L 27(R23)	0.00806	0.00579	1.45	5.06	71	2.1	10.3	6.0	61
50	$ 8	0.00500	0.00547	1.70	5.16	75		**	3.0	
50	9	0.00546	0.00498	1.69	5.20	72			2.2	
50	f 10(R9)	0.00546	0.00526	1.68	5.24	72	1.4		2.0	
50	11(R8)	0.00500	0.00292	1.74	5.01	73			2.0	
50	L 28(R8)	0.00496	0.00371	1.78	4.86	71			7.0	18
The following runs conducted with stabilized bed. The bed was stabilized with wire mesh.										
20	33	0.01103	0.00921	0.87	4.72	72			4.8	4
20	34	0.01300	0.01112	0.83	4.99	72			4.4	11
20	f 35	0.01498	0.01310	0.78	5.36	71		4.4	4.5	
30	f 32	0.01000	0.00811	1.22	4.71	70		0.4	2.75	15
40	f 31	0.00805	0.00560	1.35	5.54	72		5.0	2.3	52
50	29	0.00596	0.00451	1.69	5.20	71			3.2	
50	f 30	0.00701	0.00449	1.56	5.77	72		23.9	4.0	30

See notes in the next page.

Table 3.2 Summary of the Tests Series #2; Riprap d50=1 in. and Thickness=1.5 in.

Discharge Q cfs	Run #	Bed Slope S	Water Surface Slope S	Average Depth D ft	Average Velocity V=Q/A fps	Water Temp. F	Area Washed sq. ft at bed	Area Washed sq. ft at side	Test Duration hrs.	Colored Rock Movement % by wt.
15	36	0.00800		0.80	3.91	70			3.4	0
15	37	0.01003	0.01002	0.75	4.19	72			3.2	18
15	f 38	0.01186	0.01165	0.72	4.44	71	7.1		3.1	29
15	$ 39	0.01087	0.01090	0.70	4.60	71			3.5	
20	f 40	0.00988	0.00900	0.85	4.82	70	7.9		3.3	28
20	$ 41	0.00891	0.00832	0.89	4.58	70			3.5	29
30	f 42	0.00805	0.00711	1.17	4.98	71	55.7	2.4	3.2	71
30	$ 43	0.00607	0.00482	1.27	4.48	73			3.5	30
30	f 44	0.00703	0.00649	1.24	4.63	74	5.6	<0.1	4.2	31
40	f 45	0.00502	0.00464	1.54	4.70	72	1.3		4.0	
40	$ 46	0.00402	0.00408	1.62	4.38	75			3.8	19
50	$ 47	0.00310	0.00287	1.85	4.63	75			4.25	
50	f 48	0.00399	0.00434	1.75	4.96	70	0.8	** 0.05	3.8	
50	* 49	0.00399		1.73	5.05	71		**	3.0	
50	* 50	0.00399		1.70	5.15	71	0.4	**	3.0	

f Failure of riprap

$ Incipient failure conditions

* Runs #49 and 50 are continuation of run #48 without reshaping the riprap in the channel.

** Slumping of side-slope occurred along the top from Station 100 to 167; not included in the area washed.

Table 3.1 (Continued)

Notes:

- (R1) means repeating run #1
- f Failure of riprap
- $ Incipient failure conditions
- l. Tests with longer time period
- ** In run #8 slumping of side-slope occurred along the top from Station 98 to 131 and from Station 136 to 142; not included in the area washed.

Other Remarks

In run #4 failure occurred at the exit section because of low tailwater.
In run #6 failure occurred because of low riprap thickness at Station 101.
In run #23 failure occurred because of local geometry imperfection of the channel side-slope.
In runs #9 and #25 failure occurred because of local detachments and subsequent projection of the wooden strip from beneath the filter blanket during the test.

Table 3.3 Summary of the Tests Series #3; Riprap d50=0.5 in. and Thickness=0.75 in.

Discharge Q cfs	Run #	Bed Slope S	Water Surface Slope S	Average Depth D ft	Average Velocity V=Q/A fps	Water Temp. F	Area Washed sq. ft. at bed	Area Washed sq. ft. at side	Test Duration hrs.
15	1	0.00301	0.00203	1.10	2.67	74			3.3
15	$ 2	0.00393	0.00269	1.02	2.93	67			3.0
15	f 3	0.00481	0.00207	0.98	3.07	70	21		2.2
15	f 4	0.00600	No data collected - rapid failure						1.0
15	5	0.00454	0.00197	0.96	3.15	66			2.9
15	f 21(R2)	0.00400	0.00375	1.03	2.90	69		<0.1	2.25
20	15	0.00301	0.00295	1.12	3.49	75			0.75
20	f 16	0.00398	0.00400	1.06	3.73	71	0.1	0.6	2.0
20	$ 17	0.00343	0.00347	1.08	3.65	71			2.0
30	10	0.00146	0.00242	1.62	3.30	68			2.25
30	$ 11	0.00191	0.00234	1.57	3.43	68			2.25
30	f 12	0.00248	0.00221	1.64	3.24	71		0.4	2.6
30	13	0.00301	0.00206	1.51	3.61	71			2.4
30	f 14(R13)	0.00301	0.00322	1.47	3.73	74	17.0	2.1	3.0
30	f 23(R12)	0.00261	0.00270	1.34	4.19	67	97.5	6.3	1.25
35	f 18	0.00197	0.00240	1.76	3.45	73		2.0	2.5
35	f 19	0.00251	0.00250	1.69	3.64	73		2.5	2.0
35	20	0.00297	No data collected - rapid failure						0.25
40	f 6	0.00305	0.00241	1.69	4.16	67	58	** 14	2.0
40	f 7	0.00204	0.00170	1.75	3.98	68	84	48.5	2.5
40	f 8	0.00119	0.00268	1.80	3.83	67	10	0.15	2.0
40	$ 9	0.00087	0.00159	1.96	3.42	68			2.9
40	$ 22(R9)	0.00092	0.00158	2.22	2.90	66			1.9

(R2) means repeating run #2

f Failure of riprap

$ Incipient failure conditions

** In run #6 slumping of side-slope occurred along the top from Stations 100 to 170; not included in the area washed.

Other remarks:

In runs #3 and #4 failure occurred at the entrance section because of entrance condition. Run #2 was repeated in run #21 at a higher water surface slope, the riprap failed in run #21. Run #13 was repeated in run #14 at a higher water suface slope, the riprap failed in run #14. It was difficult to set the water surface slope close to the bed slope for discharges higher than 30 cfs because of relatively low bed slopes.

of the riprap at the failure location. The riprap thickness was increased to match the rest of the bed and the test was repeated in run #7. Run #7 did not fail and, therefore, the runs #6 and 7 were considered to be incipient failure runs since run #5 at a slope of 0.01300 had failure of the riprap.

4. The lower discharge limit was set at 15 cfs for all test series. The upper discharge limit was determined by setting the water depth less than or equal to the side-sloped channel depth when the bed slope was about the slope at the incipient failure condition. The upper limit discharge for d_{50} = 1 in. riprap was 50 cfs and for d_{50} = 0.5 in. riprap was 40 cfs.

5. When testing with the upper limit discharges, the riprap on the side-slope slumped at the top of the side-slope. This slump exposed a strip area of blanket at the top of the side-slope. This area of the underlying filter blanket that was exposed was not considered as the area washed. Additional slumping of the riprap was not observed after replacing the riprap on the slumped areas in each test series.

6. A higher proportion of the riprap failure (area washed) occurred on the bed as indicated in Tables 3.1 to 3.3.

B. <u>Remarks on Test Series #1</u>

Test series #1 involved riprap with d_{50} = 1.0 in. and a layer of riprap 2 in. thick. Discharges ranged from 15 to 50 cfs.

1. Most of the riprap failure (area washed) occurred on the bed and not on the side-slope as indicated in Table 3.1.

2. Run #1 was repeated in run #2 to collect velocity data at Stations 120 and 140 which were not collected during run #1.

3. The riprap failure in run #6 was a result of low riprap thickness at Station 101. The test was repeated in run #7 after increasing the riprap to the correct thickness at the failure location. Riprap failure was not observed at the end of run #7.

4. The riprap failure in run #23 was because of the local geometry imperfection of the channel side-slope. The channel was reshaped and the test repeated in run #24 which showed no failure.

5. In runs #9 and #25, the riprap failed on the side-slope because of local detachment and subsequent projection of the wooden strip from beneath the filter blanket during the test.

The remarks for the tests performed with longer period of time and with the stabilized bed will be discussed later in this section.

C. Remarks on Test Series #2

Test series #2 involved riprap with d_{50} = 1.0 in. and riprap layer thickness of 1.5 in. Discharges ranged from 15 to 50 cfs.

1. Riprap failures generally occurred on the bed as indicated in Table 3.2.

2. Runs #49 and 50 are a continuation of run #48 without reshaping the riprap. The exposed area of the blanket that was observed in run #48 was covered by rocks during run #49 and run #49 did not show any riprap failure. After run #50, riprap failure was observed at a location different than the failure location observed in run #48.

D. Remarks on Test Series #3

Test series #3 involved riprap with d_{50} = 0.5 in. and riprap layer thickness of 0.75 in. Discharges ranged from 15 to 40 cfs.

1. Riprap failures occurred both at the bed and at the side-slope as indicated in Table 3.3.

2. The riprap failure in runs #3 and 4 occurred at the entrance section which was because of a higher bed slope of the transition section. The transition section was reshaped and run #5 was conducted which indicated a stable riprap layer.

3. Run #2 was repeated in run #21 with a higher water surface slope which showed riprap failure at a few locations on the side-slope with a total area washed of less than 0.1 ft^2.

4. Run #13 was repeated in run #14 at a higher water surface slope. The riprap failed in run #14.

5. The bed slope required to achieve a stable riprap for discharges higher than 30 cfs was relatively low and it was difficult to set the water surface slope close to the bed slope.

3.2 Rock Movement Observation

To observe the rocks movement, the riprap was painted in strips on the side-slope and on the channel bed as shown in Figure 3.1. On the side-slope, longitudinal strips, about 2 feet long and 1.2 feet apart, were painted at stations 120, 130, and 140. On the bed, the transverse strips of painted rocks were across the bed at stations 120 and 140. The colored rocks for the bed were first painted and then placed in strips. The total weight of the colored rocks for each strip was determined before each test. After each test,the colored rocks that were moved during the test were collected air dried, and weighed. The percentage of the colored rocks that were moved are presented in Tables 3.1 and 3.2.

For incipient failure runs, from 19% to 49% of the bed colored rocks were moved downstream. Some of the colored rocks moved a distance of 50 feet, from

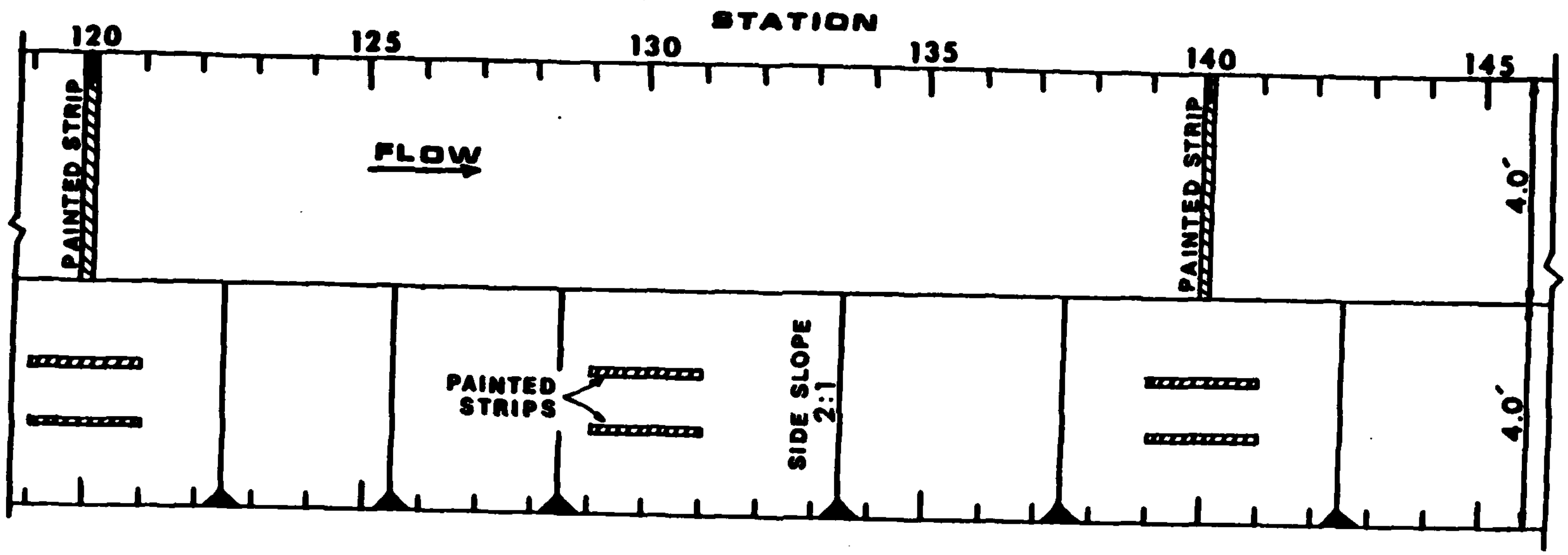

Figure 3.1 Location of the Painted Strips of Riprap in the Channel.

Station 120 to the downstream end of the channel, Station 170. Typical pattern of the colored rocks after movement are shown in Figures 3.2 and 3.3. The colored rocks on the side-slope moved downslope and downstream as shown in Figure 3.4.

3.3 Tests with Longer Period of Time

Three of the tests, which showed appreciable rock movement but not failure, were repeated for 6 to 8 hours to check if the riprap would fail after longer testing times. These tests are run # 26, 27, and 28 that are identified by "L" in Table 3.1. Only in run #27, with 40 cfs flow rate and 0.8% slope, did the riprap fail after 6 hours of testing. The test at 40 cfs and 0.8% slope was a unique test. This test was repeated three times (run # 23, 24, and 27). A small wash area (0.65 ft^2) was observed at run #23. The test was repeated (run #24) and the riprap did not fail. The riprap failed at run #27 after 6 hours of testing. Therefore, the test with 40 cfs and 0.8% slope is considered a "failure test".

The incipient failure runs #8 and #22 in Table 3.1 were repeated in runs #28 and 26, with 7 and 8 hours testing time, respectively. The riprap did not fail at 7 and 8 hours of testing time in runs #28 and 26.

3.4 Tests With Stabilized Bed

The first series of tests showed that the riprap mostly failed at the bed and not at the side slope of the channel. To determine the conditions of riprap failure at the side slope, the channel bed was stabilized and seven more tests (runs #29 to 35) were performed. The channel bed was stabilized by placing and fixing a wire mesh (chicken wire) on the bed. In the tests with the stabilized bed, the transverse strips of painted rocks were placed on the side-slope at Stations 125 and 135. The results showed that for a given discharge, a greater bed slope was necessary to fail the riprap on the side-slope than the riprap on the bed.

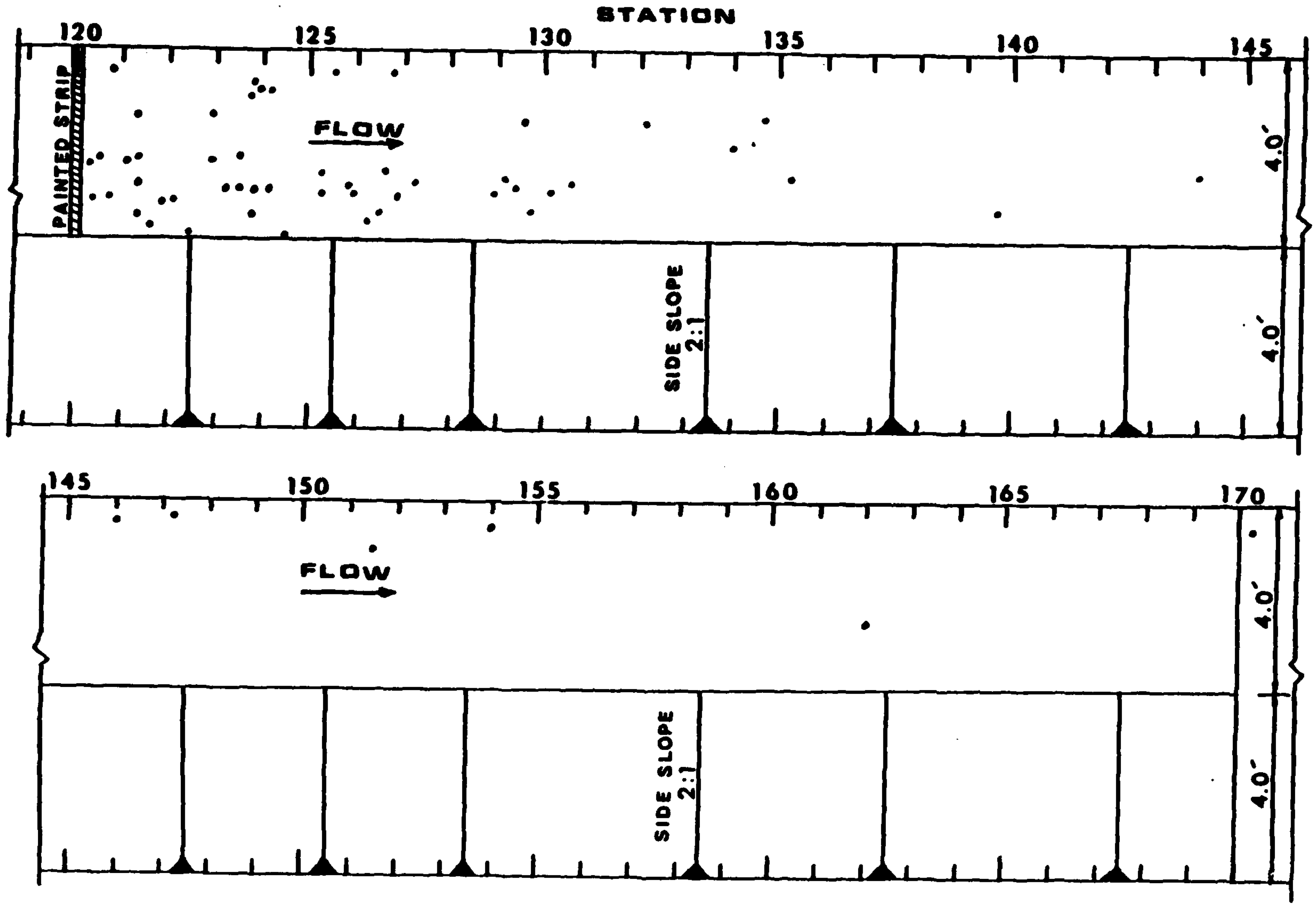

Figure 3.2 Locations of the Colored Rocks Moved From the Painted Strip at Station 120. Test Run #18, Q = 30 cfs, d_{50} = 1 in., Thickness = 2 in.

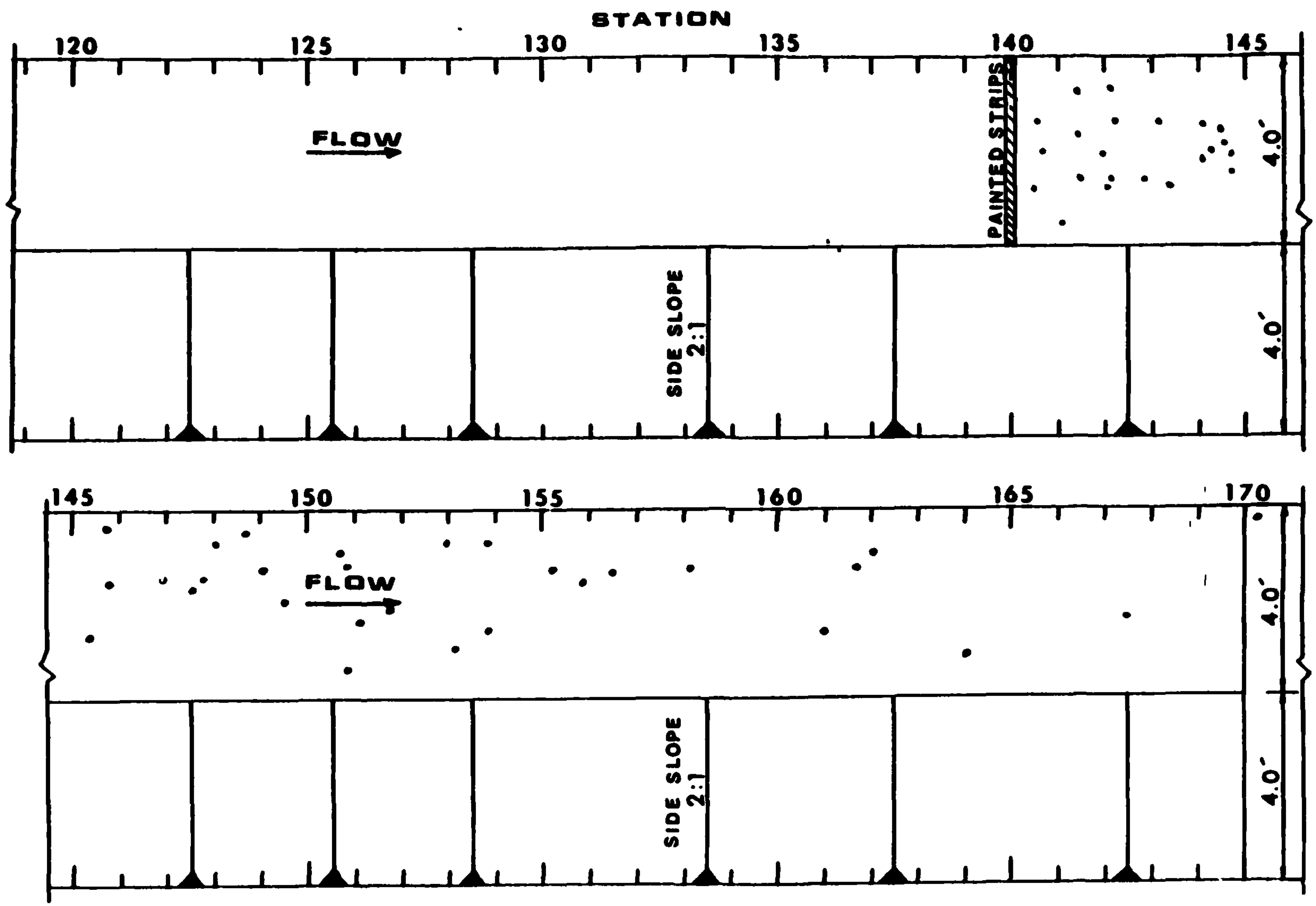

Figure 3.3 Locations of the Colored Rocks Moved From the Painted Strip at Station 140 Test Run #18, Q = 30 cfs, d_{50} = 1 in., Thickness = 2 in.

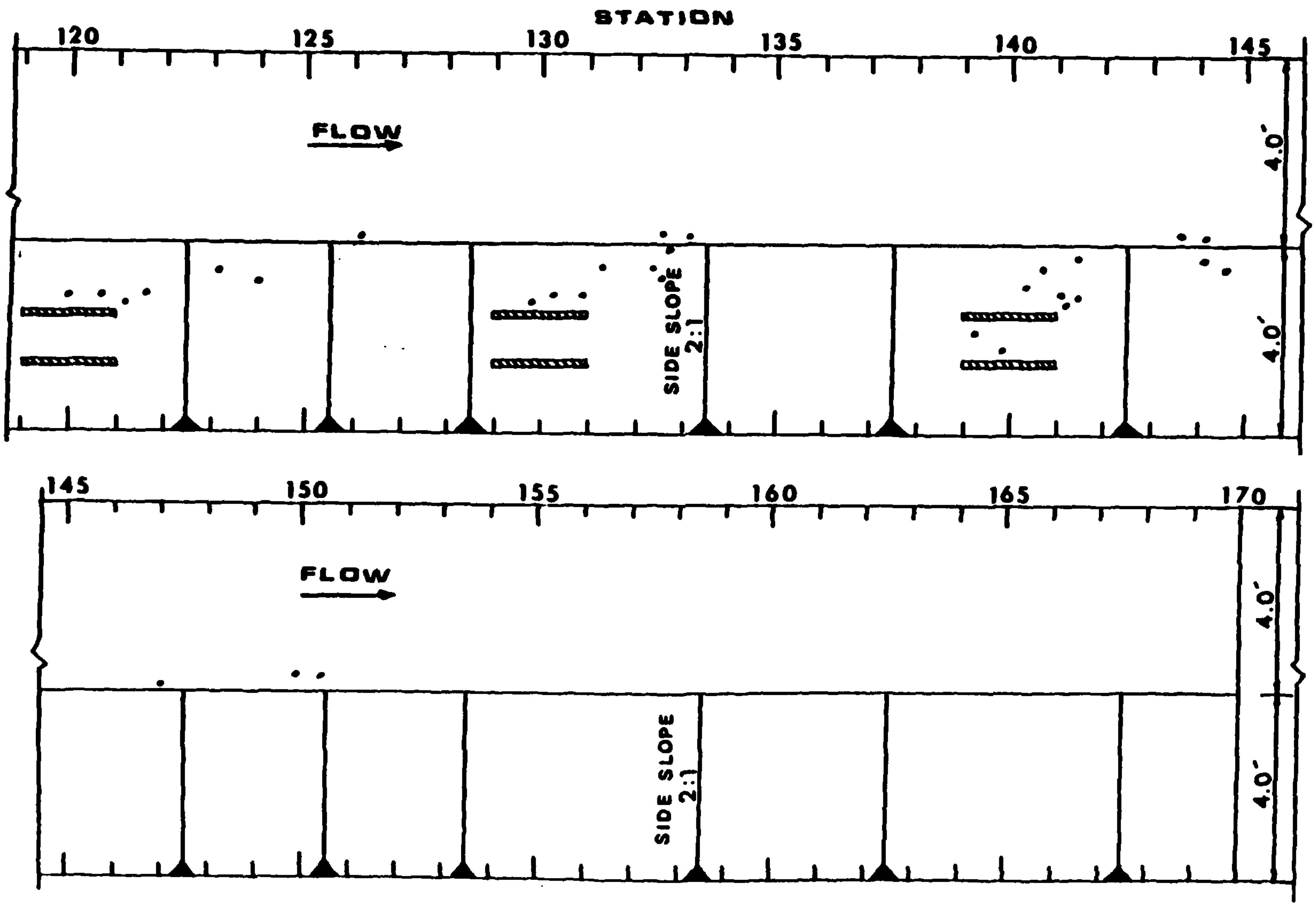

Figure 3.4 Locations of the Colored Rocks Moved from the Painted Strips on the Side Slope. Test Run #18, Q = 30 cfs, d_{50} = 1 in., Thickness = 2 in.

CHAPTER 4

DATA ANALYSIS

4.1 Calculation of Manning's Roughness Factor

The overall and bed (riprap surface) Manning's roughness factor is calculated using the following equations:

$$n = \frac{1.49}{Q} AR^{2/3} S^{1/2} \tag{4.1}$$

$$n_b = \left[\frac{n^{3/2} p - n_w^{3/2} p_w}{p_b}\right]^{2/3} \tag{4.2}$$

where

n, n_b, n_w, = Manning's roughness factor for the channel (overall), bed (riprap surface), and wall respectively

Q	= discharge in cfs,	
S	= channel slope in ft/ft,	
p	= wetted perimeter of channel	= w + 3.236D in ft,
p_b	= wetted perimeter for bed	= w + 2.236D in ft,
p_w	= wetted perimeter for walls	= D, in ft,
R	= hydraulic radius of channel	= A/p, in ft,
R_b	= hydraulic radius for bed	= A_b/p_b, in ft,
R_w	= hydraulic radius for walls	= A_w/p_w, in ft,

w	= channel width = 4 ft,
D	= water depth in ft, and
A, A_b, A_w	= flow cross-sectional area for the channel, bed and wall, respectively in ft.

For development of Equation 4.2 see references 3, 4, and 5.

Substituting the values of $p_b = w = 4$ ft, $p_w = D$, and $n_w = 0.012$ (for smooth painted wall and Plexiglas, Chow, 1959, p. 110-111) in Equation 4.2 results in:

$$n_b = \left[\frac{n^{3/2}\, p - (0.012)^{3/2}\, (D)}{4 + 2.236D}\right]^{2/3} \tag{4.3}$$

Values of n and n_b are calculated using both flume bed slope and water surface slope and are presented in Tables 4.1 to 4.3. The average value of n for $d_{50} = 1$ in. riprap is 0.022 and for $d_{50} = 0.5$ in. riprap is 0.020. The average value of n_b for $d_{50} = 1$ in. riprap is 0.023 and for $d_{50} = 0.5$ in. riprap is 0.022.

4.2 Calculation of Shields' Coefficient

The Shields coefficient, C, is defined as (Simons and Senturk, 1977, P. 409)

$$C = \frac{\tau}{(\gamma_s - \gamma_w) d_{50}} \tag{4.4}$$

Table 4.1 Calculation of Manning's and Shields' Coefficients for 1.0 in. Riprap 2.0 in. Thick

Discharge Q cfs	Run #	Bed Slope S	Water Surface Slope S	Average Depth D ft	Flow Area A=B(w+D) sq. ft	Wetted Premeter p=w+3.236D ft	Hydraulic Radius R=A/p ft	Average Velocity V=Q/A fps	Using Bed Slope: Shear Stress 62.4RS psf	Using Bed Slope: Overall Manning Coef. n	Using Bed Slope: Bed Manning Coef. n_b	Using Bed Slope: Overall Shields Coef. C=RS/1.65D50	Using Water Surface Slope: Shear Stress 62.4RS psf	Using Water Surface Slope: Overall Manning Coef. n	Using Water Surface Slope: Bed Manning Coef. n_b	Using Water Surface Slope: Overall Shields Coef. C=RS/1.65D50
15	1	0.00813	0.00768	0.81	3.90	6.62	0.59	3.85	0.30	0.025	0.026	0.035	0.28	0.024	0.025	0.033
15	2	0.00813	0.00745	0.82	3.95	6.65	0.59	3.80	0.30	0.025	0.027	0.035	0.28	0.024	0.025	0.032
15	3	0.01003	0.00929	0.77	3.67	6.49	0.57	4.08	0.35	0.025	0.026	0.041	0.33	0.024	0.025	0.038
15	f 4	0.01204	0.01127	0.73	3.45	6.36	0.54	4.34	0.41	0.025	0.026	0.048	0.38	0.024	0.026	0.044
15	f 5	0.01300	0.01077	0.70	3.29	6.27	0.53	4.56	0.43	0.024	0.026	0.050	0.35	0.022	0.023	0.041
15	• 6	0.01237	0.00907	0.69	3.24	6.23	0.52	4.64	0.40	0.023	0.024	0.047	0.29	0.020	0.021	0.034
15	• 7	0.01237	0.00957	0.71	3.34	6.30	0.53	4.49	0.41	0.024	0.026	0.048	0.32	0.021	0.022	0.037
20	12	0.00789	0.00491	0.96	4.76	7.11	0.67	4.20	0.33	0.024	0.026	0.038	0.21	0.019	0.020	0.024
20	13	0.00887	0.00804	0.89	4.35	6.88	0.63	4.60	0.35	0.023	0.024	0.041	0.32	0.021	0.023	0.037
20	• 14	0.00973	0.00945	0.86	4.18	6.78	0.62	4.79	0.38	0.022	0.024	0.045	0.36	0.022	0.023	0.042
20	f 15	0.01007	0.01074	0.85	4.12	6.75	0.61	4.85	0.41	0.023	0.024	0.048	0.41	0.023	0.024	0.048
30	16	0.00700	0.00685	1.21	6.30	7.92	0.80	4.76	0.35	0.023	0.024	0.041	0.34	0.022	0.024	0.040
30	17	0.00797	0.00723	1.15	5.92	7.72	0.77	5.07	0.38	0.022	0.024	0.044	0.35	0.021	0.022	0.040
30	• 18	0.00896	0.00677	1.13	5.88	7.66	0.76	5.10	0.42	0.023	0.024	0.049	0.32	0.020	0.021	0.037
30	f 19	0.00995	0.00796	1.09	5.55	7.53	0.74	5.41	0.46	0.022	0.024	0.053	0.37	0.020	0.021	0.043
40	20	0.00510	0.00515	1.53	8.46	8.95	0.95	4.73	0.30	0.022	0.023	0.035	0.30	0.022	0.024	0.035
40	21	0.00604	0.00595	1.47	8.04	8.76	0.92	4.97	0.35	0.022	0.024	0.040	0.34	0.022	0.024	0.040
40	• 22	0.00701	0.00536	1.42	7.70	8.60	0.90	5.20	0.39	0.022	0.024	0.046	0.30	0.019	0.021	0.035
40	f 23	0.00800	0.00669	1.39	7.49	8.50	0.88	5.34	0.44	0.023	0.025	0.051	0.37	0.021	0.023	0.043
40	24	0.00800	0.00779	1.44	7.83	8.66	0.90	5.11	0.45	0.024	0.026	0.053	0.44	0.024	0.026	0.051
40	f 25	0.00895	0.00729	1.35	7.22	8.37	0.86	5.54	0.48	0.023	0.025	0.056	0.39	0.021	0.022	0.046
40	L 26	0.00707	0.00560	1.55	8.60	9.02	0.95	4.65	0.42	0.026	0.029	0.049	0.33	0.023	0.025	0.039
40	L 27	0.00806	0.00579	1.45	7.90	8.69	0.91	5.06	0.46	0.025	0.027	0.053	0.33	0.021	0.023	0.038
50	• 8	0.00500	0.00547	1.70	9.69	9.50	1.02	5.16	0.32	0.021	0.022	0.037	0.35	0.022	0.023	0.041
50	9	0.00546	0.00498	1.69	9.62	9.47	1.02	5.20	0.35	0.021	0.023	0.040	0.32	0.020	0.022	0.037
50	f 10	0.00546	0.00526	1.68	9.54	9.44	1.01	5.24	0.34	0.021	0.023	0.040	0.33	0.021	0.022	0.039
50	11	0.00500	0.00292	1.74	9.99	9.63	1.04	5.01	0.32	0.022	0.023	0.038	0.19	0.016	0.017	0.022
50	L 28	0.00496	0.00371	1.78	10.29	9.76	1.05	4.86	0.33	0.022	0.024	0.038	0.24	0.019	0.021	0.028
The following tests were conducted with stabilized bed. The bed was stabilized with a wire mesh.																
20	33	0.01103	0.00921	0.87	4.24	6.82	0.62	4.72	0.43	0.024	0.026	0.050	0.36	0.022	0.023	0.042
20	34	0.01300	0.01112	0.83	4.01	6.69	0.60	4.99	0.49	0.024	0.026	0.057	0.42	0.022	0.024	0.048
20	f 35	0.01498	0.01310	0.78	3.73	6.52	0.57	5.36	0.53	0.023	0.025	0.062	0.47	0.022	0.023	0.054
30	f 32	0.01000	0.00811	1.22	6.37	7.95	0.80	4.71	0.50	0.027	0.030	0.058	0.41	0.025	0.026	0.047
40	f 31	0.00805	0.00560	1.35	7.22	8.37	0.86	5.54	0.43	0.022	0.024	0.051	0.30	0.018	0.019	0.035
50	29	0.00596	0.00451	1.69	9.62	9.47	1.02	5.20	0.38	0.022	0.024	0.044	0.29	0.019	0.021	0.033
50	f 30	0.00701	0.00449	1.56	8.67	9.05	0.96	5.76	0.42	0.021	0.023	0.049	0.27	0.017	0.018	0.031
								Average		0.023	0.024			0.021	0.023	

f Failure conditions
• Incipient failure conditions
L Tests with longer time period

Table 4.2 Calculation of Manning's and Shields' Coefcients for 1.0 in. Riprap, 1.5 in. Thick

									Using Bed Slope				Using Water Surface Slope			
Discharge Q cfs	Run #	Bed Slope S	Water Surface Slope S	Average Depth D ft	Flow Area A=D(w+D) sq. ft	Wetted Premeter p=w+3.236D ft	Hydraulic Radius R=A/p ft	Average Velocity V=Q/A fps	Shear Stress 62.4RS psf	Overall Manning Coef. n	Bed Manning Coef. n_b	Overall Shields Coef. C=RS/1.68d50	Shear Stress 62.4RS psf	Overall Manning Coef. n	Bed Manning Coef. n_b	Overall Shields Coef. C=RS/1.68d50
15	36	0.00800		0.80	3.83	6.58	0.58	3.91	0.29	0.024	0.025	0.034				
15	37	0.01003	0.01002	0.75	3.58	6.44	0.56	4.19	0.35	0.024	0.025	0.041	0.35	0.024	0.025	0.041
15	f 38	0.01106	0.01165	0.72	3.38	6.32	0.53	4.44	0.40	0.024	0.025	0.046	0.39	0.024	0.025	0.045
15	\$ 39	0.01087	0.01090	0.70	3.26	6.25	0.52	4.60	0.35	0.022	0.023	0.041	0.36	0.022	0.023	0.041
20	f 40	0.00908	0.00900	0.85	4.15	6.76	0.61	4.82	0.38	0.022	0.023	0.044	0.34	0.021	0.022	0.040
20	\$ 41	0.00891	0.00832	0.89	4.37	6.89	0.63	4.58	0.35	0.023	0.024	0.041	0.33	0.022	0.023	0.038
30	f 42	0.00805	0.00711	1.17	6.02	7.77	0.77	4.98	0.39	0.023	0.024	0.045	0.34	0.021	0.023	0.040
30	\$ 43	0.00607	0.00482	1.27	6.70	8.12	0.83	4.48	0.31	0.023	0.025	0.036	0.25	0.020	0.022	0.029
30	f 44	0.00703	0.00649	1.24	6.48	8.01	0.81	4.63	0.36	0.023	0.025	0.041	0.33	0.023	0.024	0.038
40	f 45	0.00502	0.00464	1.54	8.52	8.98	0.95	4.70	0.30	0.022	0.023	0.035	0.27	0.021	0.022	0.032
40	\$ 46	0.00402	0.00408	1.62	9.14	9.26	0.99	4.38	0.25	0.021	0.023	0.029	0.25	0.022	0.023	0.029
50	\$ 47	0.00310	0.00287	1.85	10.79	9.97	1.08	4.63	0.21	0.019	0.020	0.024	0.19	0.018	0.019	0.023
50	f 48	0.00399	0.00434	1.75	10.07	9.67	1.04	4.96	0.26	0.019	0.021	0.030	0.28	0.020	0.022	0.033
50	49	0.00399		1.73	9.91	9.60	1.03	5.05	0.26	0.019	0.020	0.030				
50	f 50	0.00399		1.70	9.71	9.51	1.02	5.15	0.25	0.019	0.020	0.030				
										0.022	0.023			0.021	0.023	

f Failure conditions

\$ Incipient failure conditions

Table 4.3 Calculation of Manning's and Shields' Coefficients for 0.5 in. Riprap, 0.75 in. Thick

Discharge Q cfs		Run #	Bed Slope S	Water Surface Slope S	Average Depth D ft	Flow Area A=D(w+D) sq. ft	Wetted Premeter p=w+3.236D ft	Hydraulic Radius R=A/p ft	Average Velocity V=Q/A fps	Using Bed Slope: Shear Stress 62.4RS psf	Using Bed Slope: Overall Manning Coef. n	Using Bed Slope: Bed Manning Coef. n_b	Using Bed Slope: Overall Shields Coef. C=RS/1.68d50	Using Water Surface Slope: Shear Stress 62.4RS psf	Using Water Surface Slope: Overall Manning Coef. n	Using Water Surface Slope: Bed Manning Coef. n_b	Using Water Surface Slope: Overall Shields Coef. C=RS/1.68d50
15		1	0.00301	0.00203	1.10	5.61	7.56	0.74	2.67	0.14	0.025	0.027	0.032	0.09	0.021	0.022	0.022
15	♦	2	0.00373	0.00269	1.02	5.12	7.30	0.70	2.93	0.17	0.025	0.027	0.040	0.12	0.021	0.022	0.027
15	f	3	0.00481	0.00207	0.98	4.88	7.17	0.68	3.07	0.20	0.026	0.028	0.048	0.09	0.017	0.018	0.020
15		5	0.00454	0.00197	0.96	4.76	7.11	0.67	3.15	0.19	0.024	0.026	0.044	0.08	0.016	0.017	0.019
15	f	21	0.00400	0.00375	1.03	5.18	7.33	0.71	2.90	0.18	0.026	0.028	0.041	0.17	0.025	0.027	0.039
20		15	0.00301	0.00295	1.12	5.73	7.62	0.75	3.49	0.14	0.019	0.021	0.033	0.14	0.019	0.020	0.032
20	f	16	0.00398	0.00400	1.06	5.36	7.43	0.72	3.73	0.18	0.020	0.021	0.042	0.18	0.020	0.022	0.042
20	♦	17	0.00343	0.00347	1.08	5.49	7.49	0.73	3.65	0.16	0.019	0.021	0.037	0.16	0.020	0.021	0.037
30		10	0.00146	0.00242	1.62	9.10	9.24	0.99	3.30	0.09	0.017	0.018	0.021	0.15	0.022	0.024	0.035
30	♦	11	0.00191	0.00234	1.57	8.74	9.08	0.96	3.43	0.11	0.019	0.020	0.027	0.14	0.020	0.022	0.033
30	f	12	0.00248	0.00221	1.64	9.25	9.31	0.99	3.24	0.15	0.023	0.025	0.036	0.14	0.022	0.023	0.032
30		13	0.00301	0.00206	1.51	8.32	8.89	0.94	3.61	0.18	0.022	0.023	0.041	0.12	0.018	0.019	0.028
30	f	14	0.00301	0.00322	1.47	8.04	8.76	0.92	3.73	0.17	0.021	0.022	0.040	0.18	0.021	0.023	0.043
30	f	23	0.00261	0.00270	1.34	7.16	8.34	0.86	4.19	0.14	0.016	0.017	0.033	0.14	0.017	0.017	0.034
35	f	18	0.00197	0.00240	1.76	10.14	9.70	1.05	3.45	0.13	0.020	0.021	0.030	0.16	0.022	0.024	0.037
35	f	19	0.00251	0.00250	1.69	9.62	9.47	1.02	3.64	0.16	0.021	0.022	0.037	0.16	0.021	0.022	0.037
35		20	0.00297	No data were collected, early failure													
40	f	6	0.00305	0.00241	1.69	9.62	9.47	1.02	4.16	0.19	0.020	0.022	0.045	0.15	0.018	0.019	0.036
40	f	7	0.00204	0.00170	1.75	10.06	9.66	1.04	3.98	0.13	0.017	0.018	0.031	0.11	0.016	0.017	0.026
40	f	8	0.00119	0.00268	1.80	10.44	9.82	1.06	3.83	0.08	0.014	0.014	0.018	0.18	0.021	0.023	0.041
40	♦	9	0.00087	0.00159	1.96	11.68	10.34	1.13	3.42	0.06	0.014	0.014	0.014	0.11	0.019	0.020	0.026
40	♦	22	0.00092	0.00158	2.22	13.81	11.18	1.23	2.90	0.07	0.018	0.019	0.017	0.12	0.024	0.026	0.028
											0.020	0.022			0.020	0.021	

f Failure conditions

♦ Incipient failure conditions

where

τ = $\gamma_w RS$ = boundary shear stress in psf,

R = hydraulic radius in ft,

S = channel slope in ft/ft,

γ_w = unit weight of water in lb/ft^3/

γ_s = specific weight of rocks in lb/ft^3, and

d_{50} = riprap median size in ft.

Substituting $\gamma_w RS$ for τ, Equation 4.4 becomes:

$$C = \frac{\gamma_w RS}{(\gamma_s - \gamma_w) d_{50}} = \frac{RS}{(s - 1) d_{50}} \tag{4.5}$$

where

s = γ_s / γ_w , is the specific gravity of the riprap material.

Values of C are calculated using both the water surface slope and bed slope and are presented in Tables 4.1 to 4.3. Values of C and boundary Reynolds number (R_*) for incipient failure runs are presented in Tables 4.4 to 4.6 for the three test series. The boundary Reynolds number, R_*, is defined as:

$$R_* = \frac{U_* d_{50}}{\nu} = \frac{d_{50}\sqrt{gRS}}{\nu} \tag{4.6}$$

Table 4.4 Incipient Failure Shields' Coefficients for 1.0 in. Riprap, 2.0 in. Thick

Discharge Q cfs	Run #	Bed Slope S	Water Surface Slope S	Average Depth D ft	Hydraulic Radius R ft	Average Velocity V=Q/A fps	Using Bed Slope: Overall Shields' Coeficient C	Using Bed Slope: Boundary Reynolds Number R_*	Using W. S. Slope: Overall Shields' Coeficient C	Using W. S. Slope: Boundary Reynolds Number R_*
15	6	0.01237	0.00907	0.69	0.52	4.64	0.046	3793	0.034	3248
15	7	0.01237	0.00957	0.71	0.53	4.49	0.047	3829	0.036	3368
20	14	0.00993	0.00945	0.86	0.62	4.79	0.044	3710	0.042	3620
30	18	0.00896	0.00677	1.13	0.76	5.18	0.048	3902	0.037	3392
40	22	0.00701	0.00536	1.45	0.91	5.06	0.046	3777	0.035	3303
50	8	0.00500	0.00547	1.70	1.02	5.16	0.036	3377	0.040	3532

Table 4.5 Incipient Failure Shields' Coeffcients for 1.0 in. Riprap, 1.5 in. Thick

Discharge Q cfs	Run #	Bed Slope S	Water Surface Slope S	Average Depth D ft	Hydraulic Radius R ft	Average Velocity V=Q/A fps	Using Bed Slope: Overall Shields' Coefficient C	Using Bed Slope: Boundary Reynolds Number R_*	Using W. S. Slope: Overall Shields' Coefficient C	Using W. S. Slope: Boundary Reynolds Number R_*
15	39	0.01087	0.01090	0.70	0.52	4.60	0.041	3555	0.041	3560
20	41	0.00891	0.00832	0.89	0.63	4.58	0.040	3543	0.038	3424
30	43	0.00607	0.00482	1.27	0.83	4.48	0.036	3356	0.028	2991
40	46	0.00402	0.00408	1.62	0.99	4.38	0.028	2983	0.029	3005
50	47	0.00310	0.00287	1.85	1.08	4.63	0.024	2736	0.022	2633

Table 4.6 Incipient Failure Shields' Coefficients for 0.5 in. Riprap, 0.75 in. Thick

Discharge Q cfs	Run #	Bed Slope S	Water Surface Slope S	Average Depth D ft	Hydraulic Radius R ft	Average Velocity V=Q/A fps	Using Bed Slope: Overall Shields' Coefficient C	Using Bed Slope: Boundary Reynolds number R_*	Using W. S. Slope: Overall Shields' Coefficient C	Using W. S. Slope: Boundary Reynolds number R_*
15	2	0.00393	0.00269	1.02	0.70	2.93	0.039	1240	0.027	1026
20	17	0.00343	0.00347	1.08	0.73	3.65	0.036	1183	0.036	1190
30	11	0.00191	0.00234	1.57	0.96	3.43	0.026	1012	0.032	1121
40	9	0.00087	0.00159	1.96	1.13	3.42	0.014	741	0.026	1002
40	22	0.00092	0.00158	2.22	1.24	2.90	0.016	797	0.028	1044

where U_* is the shear velocity in fps and ν is the kinematic viscosity in ft ^{2}/sec. The C values for incipient failure runs calculated using the bed slope are plotted on the Shields' diagram (Simons and Senturk, 1977) as presented in figure 4.1. All C values are below the Shields' curve as shown in Figure 4.1.

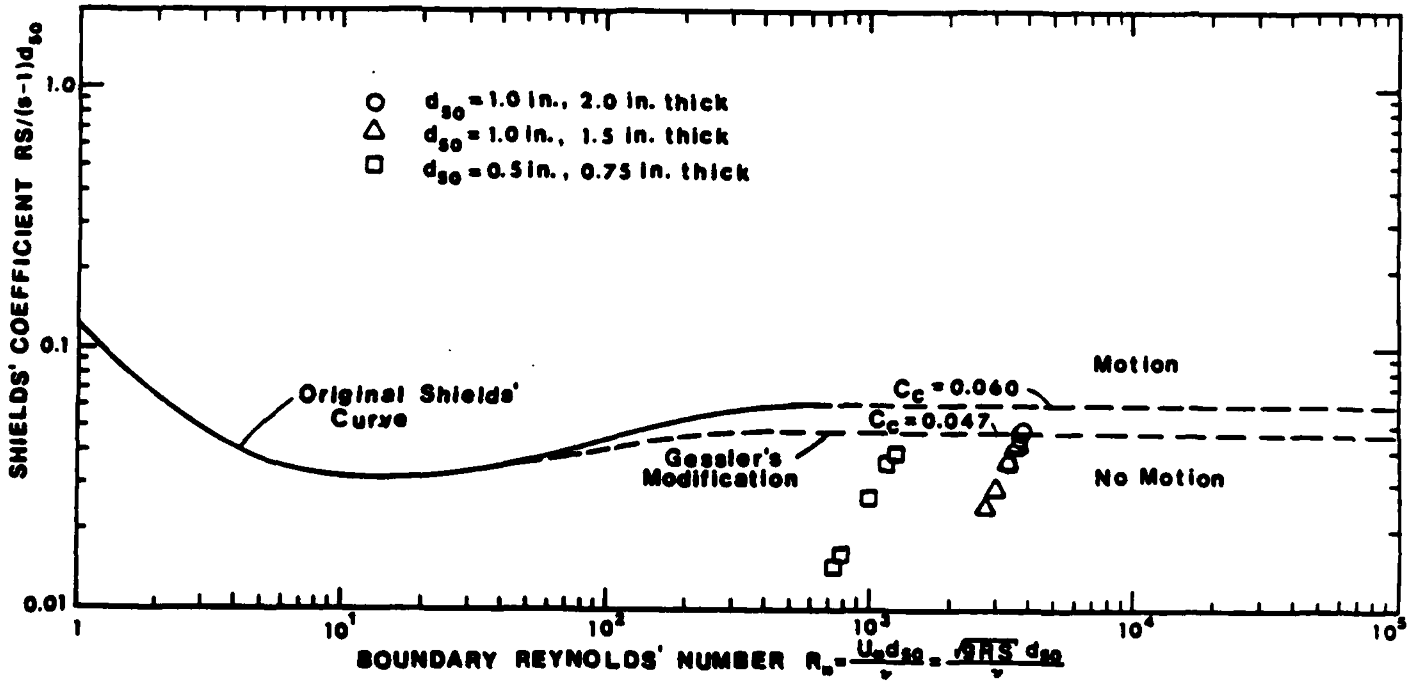

Figure 4.1 The Shields' Diagram. Bed Slope is Used to Calculate Shields' Coefficients and Boundary Reynolds Number.

CHAPTER 5

SUMMARY

A total of 73 tests were conducted on two sizes of riprap in a 2H: 1V side-slope channel. One riprap material had a d_{50} = 1 in. and was tested with thicknesses of 2 in. and 1.5 in. The other riprap had a d_{50} = 0.5 in. and was tested with a thickness of 0.75 in. Flow rates were 15, 20, 30, 40, and 50 cfs for the d_{50} = 1 in. riprap and 15, 20, 30, 35, and 40 cfs for the d_{50} = 0.5 in. riprap. For each riprap and each flow rate the bed slope of the channel was increased by small increments until the riprap failed. The exposure of the filter blanket underneath the riprap was the failure criterion. The run with the next lower channel slope prior to the failure run was considered to be the incipient failure run.

Summaries of the tests are presented in Tables 3.1 to 3.3 and the detailed velocity data are presented in the Appendix. Values of Manning's roughness factors and Shields' coefficients for all runs are calculated and presented in Tables 4.1 to 4.3. The Manning's roughness factor of the riprap surface for d_{50} = 1 in. riprap is 0.023 and for d_{50} = 0.5 in. riprap is 0.022. The Shields' coefficients for incipient failure runs are presented in Tables 4.4 to 4.6. The lower values of Shields coefficient are for higher discharges. The ranges of Shields' coefficients are:

C = .036 to .047 for d_{50} = 1 in., 2 in thick riprap

C = .024 to .041 for d_{50} = 1 in. 1.5 in. thick riprap

C = .014 to .039 for d_{50} = 0.5 in, 0.75 in thick riprap

Riprap movement was observed using painted rocks. Strips of riprap were painted with different colors prior to the tests. At the end of each test run, the locations of the painted rocks were observed and recorded. The rock detached from the bed moved in a path generally straight down the channel. Rocks detached from the side slope moved at an angle down the channel side slope until they reached the bed. The rocks then were swept downstream but remained near the toe.

Three tests designated as incipient failure, were conducted for time periods of six to eight hours to observe the influence of the flow on the riprap for longer times. The riprap did not fail in two of the three runs.

Several tests also were conducted with a stabilized bed to determine the conditions of riprap failure on the side-slope. The results showed that for a given discharge, a greater bed slope was necessary to fail the riprap on the side-slope than the riprap on the bed.

For d_{50} = 1 in. rock, the riprap failure generally occurred at the bed and not at the side-slope. For d_{50} = 0.5 in. rock, the riprap failed both at the bed and at the side-slope with the higher portion of the area washed occurring at the bed. The areas washed on the bed and on the side-slope are presented in Tables 3.1 to 3.3.

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APPENDIX

VELOCITY DATA

VELOCITY DATA

The notations used in the appendices are as follows:

Q	=	discharge, cfs
X	=	station along the flume, starting at the upstream end of the flume, ft
Y	=	distance across the flume from the right wall of the flume, ft
Z	=	depth at which velocity was measured, vertical distance above the bottom, ft
Rock Size	=	the median size or d_{50} of the riprap, in.
Thickness	=	thickness of the riprap, in.
Temp.	=	water temperature, °F

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 1 — Bed Slope= 0.00813 — Rock size= 1 in. — Side slope 2:1
Q=15 cfs — Water Surface Slope= 0.00768 — Thickness= 2 in. — Temp= 74 F

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Fraction of Depth	Velocity ft/sec	Location Y=4.0' Depth Z, ft	Velocity ft/sec	Location Y=3.5' Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.243	0.81	1.00		0.85		71.243	0.53	
X=130'	71.154	0.72	0.90	5.08	0.76	4.49	71.197	0.49	3.77
	70.993	0.56	0.70	4.94	0.60	4.05	71.088	0.38	3.51
	70.833	0.40	0.50	4.36	0.44	3.51	70.980	0.27	2.84
	70.753	0.32	0.40	4.05	0.36	3.51	70.872	0.16	2.64
	70.673	0.24	0.30	3.70	0.28	3.11	70.736	0.03	1.72
	70.592	0.16	0.20	3.51	0.20	2.74	70.709	0.00	
	70.552	0.12	0.15	3.11	0.16	2.37			
	70.512	0.08	0.10	2.88	0.12	1.94			
	70.472	0.04	0.05	2.37	0.08	1.47			
	70.432	0.00	0.00						
		Average Velocity		4.13		3.27			2.86

Run # 2 — Bed Slope= 0.00813 — Rock size= 1 in. — Side slope 2:1
Q=15 cfs — Water Surface Slope= 0.00745 — Thickness= 2 in. — Temp= 74 F

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Fraction of Depth	Velocity ft/sec	Location Y=4.0' Depth Z, ft	Velocity ft/sec	Location Y=3.5' Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.261	0.82	1.00		0.78		71.261	0.60	
X=120'	71.189	0.75	0.90	5.38	0.71	4.36	71.201	0.54	3.51
	71.023	0.58	0.70	4.86	0.54	3.84	71.105	0.44	3.36
	70.857	0.42	0.50	4.33	0.38	3.70	71.010	0.35	2.93
	70.773	0.33	0.40	4.21	0.29	3.02	70.914	0.25	2.54
	70.690	0.25	0.30	3.70	0.21	2.88	70.794	0.13	2.20
	70.607	0.17	0.20	3.23	0.13	2.32	70.680	0.02	0.00
	70.524	0.08	0.10	2.64	0.04	2.14			
	70.483	0.04	0.05	1.72	0.00	1.64			
	70.441	0.00	0.00						
	70.391			1.16					
		Average Velocity		4.08		3.36			2.56

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Fraction of Depth	Velocity ft/sec	Location Y=4.0' Depth Z, ft	Velocity ft/sec	Location Y=3.5' Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.261	0.81	1.00		0.79		71.261	0.52	
X=140'	71.187	0.74	0.90	5.31	0.71	4.63	71.207	0.46	3.98
	71.023	0.57	0.70	4.94	0.55	4.21	71.116	0.37	3.81
	70.859	0.41	0.50	4.63	0.38	3.81	71.026	0.28	3.36
	70.777	0.33	0.40	4.30	0.30	3.70	70.935	0.19	3.02
	70.695	0.25	0.30	4.14	0.22	3.15	70.822	0.08	2.43
	70.613	0.16	0.20	3.59	0.14	2.64	70.760	0.02	3.47
	70.531	0.08	0.10	1.87	0.06	2.64			
	70.490	0.04	0.05	1.79	0.02	2.59			
	70.452	0.00		0.52					
	70.449	0.00	0.00						
	70.490				0.02	2.59			
		Average Velocity		4.18		3.65			3.06

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Run # 3 Bed Slope= 0.01003 Rock Size= 1 in. Side slope 2:1
Q=15 cfs Water Surface Slope= 0.00929 Thickness= 2 in. Temp. 74 F

		Location Y=6.0'			Location Y=4.0'		Location Y=3.5'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.228	0.79	1.00		0.79		71.228	0.52	
X=120'	71.158	0.72	0.90	5.73	0.72	4.69	71.173	0.47	3.90
	70.998	0.56	0.70	4.91	0.56	4.20	71.086	0.38	3.81
	70.838	0.40	0.50	4.56	0.40	3.90	70.998	0.29	3.36
	70.757	0.32	0.40	4.41	0.32	3.55	70.910	0.20	3.28
	70.677	0.24	0.30	4.01	0.24	2.91	70.801	0.10	2.88
	70.597	0.16	0.20	3.18	0.16	2.54	70.722	0.02	2.01
	70.557	0.12	0.15	3.11	0.12	2.45			
	70.517	0.08	0.10	2.43	0.08	2.14			
	70.477	0.04	0.05	2.01	0.04	1.72			
	70.437	0.00	0.00						
		Average Velocity		4.25		3.50			3.12
	71.179	0.72	1.00		0.72		71.192	0.56	
X=130'	71.108	0.64	0.90	5.63	0.63	4.89	71.157	0.52	4.10
	70.966	0.50	0.70	5.45	0.49	4.43	71.060	0.42	3.84
	70.824	0.36	0.50	4.72	0.35	4.16	70.963	0.33	3.47
	70.753	0.28	0.40	4.57	0.28	3.95	70.866	0.23	3.02
	70.682	0.21	0.30	4.14	0.21	3.28	70.744	0.11	2.14
	70.611	0.14	0.20	3.66	0.14	3.18	70.653	0.02	1.67
	70.576	0.11	0.15	3.47	0.10	2.59			
	70.540	0.07	0.10	3.23	0.07	2.41			
	70.505	0.04	0.05	3.02	0.03	1.55			
	70.485	0.02	0.02	1.47					
	70.469	0.00	0.00						
	70.491				0.02	1.47			
		Average Velocity		4.56		3.82			3.04
	71.218	0.79	1.00		0.78		71.218	0.52	
X=140'	71.149	0.72	0.90	5.67	0.71	4.69	71.163	0.47	3.93
	70.990	0.56	0.70	5.23	0.56	4.40	71.075	0.38	3.66
	70.831	0.40	0.50	4.93	0.40	3.95	70.987	0.29	3.47
	70.751	0.32	0.40	4.47	0.32	3.55	70.899	0.21	2.96
	70.672	0.24	0.30	4.20	0.24	3.05	70.789	0.10	1.64
	70.592	0.16	0.20	3.55	0.16	2.43	70.710	0.02	0.00
	70.552	0.12	0.15	3.15	0.12	1.72			
	70.513	0.08	0.10	2.07	0.08	1.47			
	70.473	0.04	0.05	1.37	0.04	1.16			
	70.433	0.00	0.00						
	70.451				0.02	0.00			
		Average Velocity		4.37		3.46			2.80

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 4
Q=15 cfs

Bed Slope= 0.01204
Water Surface Slope= 0.01127

Temp= 72 F

Rock size= 1 in.
Thickness= 2 in.

Side slope 2:1

		Location Y=6.0'			Location Y=4.0'		Location Y=3.6'			Location Y=3.5'			Location Y=3.3'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.171	0.75	1.00		0.66		71.171	0.56		71.171	0.48		71.171	0.42	
X=120'	71.111	0.68	0.90	6.09	0.60	4.98	71.122	0.51	4.65	71.125	0.43	4.36	71.133	0.38	3.81
	70.957	0.54	0.70	5.79	0.44	4.85	71.019	0.41	4.43	71.044	0.35	4.13	71.084	0.34	3.66
	70.803	0.38	0.50	5.20	0.29	4.33	70.916	0.31	4.11	70.963	0.27	3.68	71.035	0.29	3.44
	70.726	0.31	0.40	4.93	0.21	3.57	70.812	0.20	3.84	70.882	0.19	3.47	70.986	0.24	3.32
	70.649	0.23	0.30	4.53	0.13	3.38	70.709	0.10	3.30	70.801	0.11	3.28	70.937	0.19	3.02
	70.572	0.15	0.20	3.66	0.06	2.84	70.625	0.02	2.59	70.710	0.02	2.88	70.765	0.02	2.32
	70.534	0.12	0.15	3.26											
	70.495	0.08	0.10	2.88											
	70.473	0.05	0.08	2.84											
	70.418	0.00	0.00												
		Average Velocity		4.81		4.04			3.89			3.62			3.08
	71.156	0.72	1.00		0.70					71.156	0.54				
X=130'	71.078	0.64	0.90	6.19	0.62	5.13				71.122	0.51	4.08			
	70.936	0.50	0.70	6.02	0.48	4.83				71.040	0.43	4.01			
	70.795	0.36	0.50	5.37	0.34	4.10				70.958	0.34	3.59			
	70.724	0.28	0.40	5.18	0.27	3.76				70.875	0.26	2.88			
	70.653	0.21	0.30	4.63	0.20	3.47				70.793	0.18	2.37			
	70.582	0.14	0.20	4.16	0.12	2.82				70.630	0.02	1.64			
	70.546	0.11	0.15	3.50	0.09	2.32									
	70.511	0.07	0.10	3.28	0.05	2.20									
	70.475	0.03	0.05	2.88	0.02	1.79									
	70.440	0.00	0.00												
	70.433			2.07											
	70.474					1.72									
		Average Velocity		5.03		3.95						2.96			
	71.178	0.72	1.00		0.74					71.178	0.48				
X=140'	71.116	0.65	0.90	5.72	0.65	4.69				71.128	0.43	4.27			
	70.971	0.51	0.70	5.67	0.53	4.47				71.052	0.35	4.18			
	70.826	0.36	0.50	4.90	0.38	4.27				70.977	0.28	3.88			
	70.753	0.29	0.40	4.71	0.31	3.86				70.901	0.20	3.47			
	70.681	0.22	0.30	4.26	0.24	3.22				70.806	0.10	2.48			
	70.608	0.15	0.20	4.01	0.17	2.96				70.718	0.02	1.64			
	70.572	0.11	0.15	3.86	0.13	2.23									
	70.536	0.07	0.10	3.33	0.09	2.14									
	70.499	0.04	0.05	2.64	0.06	1.87									
	70.469	0.01		2.98											
	70.463	0.00	0.00												
	70.458				0.02	2.37									
		Average Velocity		4.68		3.52						3.35			

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 5 Bed Slope= 0.01300 Temp= 74 F Rock size= 1 in. Side slope 2:1
Q=15 cfs Water Surface Slope= 0.01077 Thickness= 2 in.

		Location Y=6.0'			Location Y=4.0'			Location Y=3.7'		Location Y=3.5'		Location Y=3.3'	
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec
	71.135	0.68	1.00		0.64		71.135	0.54		0.44		0.35	
X=120'	71.092	0.64	0.90	6.24	0.60	5.23	71.072	0.48	5.05	0.38	4.49	0.29	3.84
	70.950	0.50	0.70	5.96	0.46	5.05	70.967	0.37	4.66	0.27	4.05	0.18	3.47
	70.809	0.36	0.50	5.52	0.31	4.33	70.861	0.27	4.33	0.17	3.63	0.07	3.00
	70.738	0.28	0.40	5.20	0.24	4.10	70.755	0.16	3.47	0.06	3.02		
	70.667	0.21	0.30	4.86	0.17	3.83	70.650	0.06	2.59				
	70.596	0.14	0.20	4.53	0.10	3.06	70.610	0.02	2.48				
	70.560	0.11	0.15	4.18	0.07	2.54	70.711			0.02	2.54		
	70.525	0.07	0.10	3.66	0.03	2.32	70.802					0.02	2.26
	70.489	0.04	0.05	3.63									
	70.473	0.02	0.02	3.40									
	70.454	0.00	0.00										
	70.510				0.02	2.26							
		Average Velocity		5.23		4.18			3.99		3.71		2.93
	71.150	0.71	1.00		0.67		71.150	0.56		0.50		0.35	
X=130'	71.087	0.63	0.90	6.24	0.59	5.06	71.091	0.50	4.89	0.44	4.53	0.29	4.18
	70.928	0.49	0.70	6.13	0.45	4.79	70.972	0.39	4.55	0.33	4.07	0.17	2.91
	70.788	0.35	0.50	5.47	0.31	4.27	70.853	0.27	3.91	0.21	3.63	0.05	2.14
	70.718	0.28	0.40	4.94	0.24	3.86	70.734	0.15	3.26	0.09	2.20		
	70.648	0.21	0.30	4.52	0.17	3.15	70.615	0.03	2.96				
	70.579	0.14	0.20	4.33	0.10	2.59	70.602	0.02	2.32				
	70.544	0.11	0.15	3.76	0.07	2.07	70.662			0.02	1.64		
	70.509	0.07	0.10	3.38	0.03	1.55	70.817					0.02	1.16
	70.474	0.04	0.05	2.88									
	70.440	0.00		2.59									
	70.439	0.00	0.00										
	70.494				0.02	1.47							
		Average Velocity		5.15		3.94			3.90		3.44		2.97
	71.148	0.72	1.00		0.62		71.148	0.57		0.53		0.37	
X=140'	71.071	0.64	0.90	6.28	0.55	5.50	71.088	0.51	5.12	0.47	4.60	0.31	3.91
	70.928	0.50	0.70	5.83	0.40	5.05	70.976	0.40	4.82	0.36	4.18	0.20	3.84
	70.785	0.36	0.50	5.23	0.26	4.52	70.865	0.29	4.49	0.25	3.74	0.09	1.72
	70.714	0.29	0.40	5.08	0.19	3.59	70.753	0.18	3.61	0.14	3.15		
	70.642	0.21	0.30	4.55	0.12	2.98	70.641	0.06	2.32				
	70.571	0.14	0.20	4.16	0.05	2.61	70.593	0.02	1.72				
	70.535	0.11	0.15	3.86	0.01	1.79	70.633			0.02	1.64		
	70.499	0.07	0.10	3.26			70.794					0.02	0.90
	70.464	0.04	0.05	2.79									
	70.451	0.02	0.02	2.43									
	70.428	0.00	0.00										
	70.535				0.01	1.79							
		Average Velocity		5.04		4.28			3.99		3.57		2.91

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 6 Bed Slope= 0.01237 Temp= 72 F Rock size= 1 in. Side slope 2:1
Q=15 cfs Water Surface Slope= 0.00907 Thickness= 2 in.

		Location Y=6.0'			Location Y=4.0'			Location Y=3.8'		Location Y=3.6'		Location Y=3.4'	
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec
	71.166	0.68	1.00		0.62		71.166	0.56		0.49		0.38	
X=120'	71.104	0.62	0.90	6.13	0.56	5.20	71.105	0.50	4.63	0.43	3.93	0.32	3.47
	70.966	0.48	0.70	5.33	0.42	4.83	70.992	0.39	4.40	0.31	3.57	0.20	3.06
	70.828	0.34	0.50	5.28	0.29	4.10	70.879	0.28	3.83	0.20	3.06	0.09	2.48
	70.759	0.28	0.40	5.14	0.22	3.74	70.766	0.16	3.70	0.09	2.59		
	70.690	0.21	0.30	4.74	0.15	3.42	70.653	0.05	2.32				
	70.621	0.14	0.20	4.36	0.08	3.28	70.619	0.02	2.01				
	70.587	0.10	0.15	4.05	0.04	2.88	70.685			0.02	2.07		
	70.552	0.07	0.10	3.65	0.01	2.64	70.805					0.02	0.90
	70.518	0.03	0.05	3.40									
	70.490	0.01		3.28									
	70.483	0.00	0.00										
	70.552				0.01	2.64							
		Average Velocity		5.03		4.16			3.75		3.16		2.72
	71.162	0.70	1.00		0.66		71.162	0.59		0.53		0.42	
X=130'	71.096	0.63	0.90	6.10	0.60	5.23	71.093	0.52	4.97	0.46	4.40	0.35	3.72
	70.956	0.49	0.70	5.87	0.46	4.97	70.985	0.41	4.72	0.35	4.08	0.24	3.47
	70.817	0.35	0.50	5.27	0.32	4.47	70.877	0.31	4.46	0.24	3.65	0.13	2.93
	70.747	0.28	0.40	5.01	0.25	4.20	70.768	0.20	3.65	0.13	2.96	0.02	1.55
	70.677	0.21	0.30	4.74	0.18	3.91	70.680	0.09	2.87	0.03	0.90		
	70.607	0.14	0.20	4.26	0.11	3.22	70.587	0.02	0.52				
	70.572	0.11	0.15	4.01	0.07	2.93	70.650			0.02	0.73		
	70.537	0.07	0.10	3.57	0.04	2.52	70.760					0.02	1.37
	70.502	0.03	0.05	3.23									
	70.467	0.00	0.00										
	70.461			2.74									
	70.517				0.02	2.14							
		Average Velocity		5.00		4.26			3.86		3.33		3.01
	71.149	0.69	1.00		0.64		71.149	0.59		0.47		0.40	
X=140'	71.078	0.62	0.90	6.04	0.57	5.33	71.088	0.53	4.89	0.41	4.52	0.34	3.93
	70.941	0.48	0.70	5.91	0.43	4.91	70.976	0.42	4.59	0.29	4.29	0.22	3.47
	70.804	0.34	0.50	5.27	0.29	4.41	70.863	0.30	4.26	0.18	3.54	0.11	1.87
	70.736	0.27	0.40	4.62	0.23	4.18	70.750	0.19	3.47	0.07	2.48		
	70.607	0.14	0.30	4.13	0.10	3.32	70.637	0.08	1.87				
	70.580	0.14	0.20	3.76	0.08	2.37	70.577	0.02	1.16				
	70.565	0.10	0.15	3.57	0.05	1.47	70.698			0.02	1.55		
	70.530	0.07	0.10	3.06	0.02	1.16	70.770					0.02	1.16
	70.496	0.03	0.05	2.71									
	70.467	0.01		2.01									
	70.462	0.00	0.00										
	70.527				0.02	0.90							
		Average Velocity		4.90		4.12			3.69		3.58		2.80

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 7 | Bed Slope= 0.01237 | Temp= 75 F | Rock size= 1 in. | Side slope 2:1
Q=15 cfs | Water Surface Slope= 0.00957 | Thickness= 2 in.

		Location Y=6.0'			Location Y=4.0'			Location Y=3.7'		Location Y=3.5'		Location Y=3.2'	
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec
	71.149	0.70	1.00		0.63		71.149	0.57		0.45		0.31	
X=120'	71.066	0.62	0.90	6.24	0.55	5.38	71.079	0.50	5.05	0.37	4.44	0.24	3.81
	70.928	0.48	0.70	5.74	0.41	5.05	70.961	0.38	4.56	0.26	4.18	0.12	3.32
	70.791	0.34	0.50	5.31	0.27	4.33	70.844	0.26	4.10	0.14	3.30		
	70.722	0.28	0.40	4.78	0.20	3.93	70.726	0.15	3.76				
	70.653	0.21	0.30	4.53	0.13	3.47	70.608	0.03	2.59				
	70.584	0.14	0.20	4.14	0.06	3.05	70.595	0.02	2.54				
	70.549	0.10	0.15	3.81	0.03	2.29	70.720			0.02	2.32		
	70.515	0.07	0.10	3.44			70.855					0.02	2.43
	70.480	0.03	0.05	2.84									
	70.461	0.02		2.69									
	70.446	0.00	0.00										
	70.536				0.02	2.20							
		Average Velocity		5.03		4.32			4.07		3.63		3.26
	71.166	0.71	1.00		0.61		71.166	0.54		0.48		0.33	
X=140'	71.103	0.64	0.90	6.02	0.55	5.60	71.096	0.47	5.17	0.41	4.78	0.26	3.81
	70.960	0.50	0.70	5.51	0.41	5.55	70.983	0.36	4.98	0.30	4.33	0.15	3.72
	70.817	0.36	0.50	4.98	0.28	4.49	70.871	0.25	4.26	0.19	3.63	0.04	2.52
	70.745	0.29	0.40	4.65	0.19	4.00	70.758	0.13	3.57	0.07	3.02		
	70.673	0.22	0.30	4.27	0.12	3.36	70.645	0.02	2.96				
	70.601	0.14	0.20	3.86	0.05	2.59	70.641	0.02	2.88				
	70.566	0.11	0.15	3.47			70.701			0.02	1.55		
	70.530	0.07	0.10	3.06			70.851					0.02	2.20
	70.494	0.04	0.05	2.32									
	70.465	0.01		1.61									
	70.458	0.00	0.00										
	70.570				0.01	1.84							
		Average Velocity		4.70		4.48			4.21		3.77		3.34

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 8 Q=50 cfs	Bed Slope= 0.00500 Water Surface Slope= 0.00547	Temp= 75 F	Rock size= 1 in. Thickness= 2 in.	Side slope 2:1

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Fraction of Depth	Velocity ft/sec	Location Y=4.0' Depth Z, ft	Velocity ft/sec	Elevation (ft)	Location Y=3.4' Depth Z, ft	Velocity ft/sec	Location Y=2.6' Depth Z, ft	Velocity ft/sec	Location Y=1.8' Depth Z, ft	Velocity ft/sec
	72.147	1.75	1.00		1.62		72.147	1.37	-	1.02		0.66	
X=120'	71.994	1.60	0.90	6.65	1.47	6.61	71.966	1.19	5.67	0.83	4.33	0.46	3.44
	71.639	1.24	0.70	6.43	1.11	6.55	71.647	0.87	5.37	0.52	3.98	0.16	2.01
	71.284	0.89	0.50	5.84	0.76	6.08	71.328	0.55	4.63	0.20	2.91		
	71.106	0.71	0.40	5.42	0.58	5.50	71.009	0.23	3.66				
	70.928	0.53	0.30	5.04	0.40	5.12	70.795	0.02	1.09				
	70.750	0.36	0.20	4.65	0.23	3.83	71.147			0.02	1.16		
	70.662	0.27	0.15	3.95	0.14	3.55	71.505					0.02	1.16
	70.573	0.18	0.10	3.36	0.05	2.64							
	70.484	0.09	0.05	3.05									
	70.428	0.03		2.46									
	70.395	0.00	0.00										
	70.540				0.02	2.01							
		Average Velocity		5.42		5.58			4.55		3.53		2.64
	72.139	1.69	1.00		1.59		72.137	1.44		1.07		0.67	
X=130'	71.986	1.54	0.90	6.58	1.44	6.36	71.982	1.28	5.43	0.92	4.56	0.52	3.66
	71.653	1.20	0.70	6.45	1.10	6.15	71.672	0.97	5.23	0.60	4.14	0.21	2.79
	71.311	0.86	0.50	6.01	0.76	5.59	71.363	0.67	4.90	0.30	3.02		
	71.139	0.69	0.40	5.90	0.59	5.46	71.053	0.35	4.16				
	70.968	0.51	0.30	4.90	0.41	5.04	70.714	0.02	1.37				
	70.797	0.34	0.20	4.40	0.24	4.36	71.083			0.02	0.00		
	70.711	0.26	0.15	4.00	0.16	3.81	71.482					0.02	0.00
	70.625	0.17	0.10	3.74	0.07	3.13							
	70.540	0.09	0.05	3.36									
	70.454	0.00	0.00										
	70.453			2.48									
	70.570				0.02	2.59							
		Average Velocity		5.49		5.39			4.46		3.35		2.73
	72.116	1.67	1.00		1.50		72.116	1.37		1.02		0.58	
X=140'	71.956	1.52	0.90	6.71	1.34	6.40	71.970	1.22	5.45	0.87	4.66	0.43	3.93
	71.619	1.18	0.70	6.61	1.00	6.17	71.668	0.92	5.32	0.57	4.26	0.13	3.05
	71.283	0.84	0.50	5.81	0.68	5.56	71.367	0.62	4.83	0.27	3.51		
	71.114	0.67	0.40	5.30	0.49	5.43	71.065	0.32	4.01				
	70.946	0.50	0.30	4.98	0.33	4.71	70.785	0.02	1.64				
	70.778	0.34	0.20	4.41	0.16	3.86	71.112			0.02	0.00		
	70.693	0.25	0.15	4.18	0.07	3.02	71.554					0.02	0.00
	70.609	0.17	0.10	3.51									
	70.525	0.08	0.05	2.72									
	70.441	0.00	0.00										
	70.420			0.00									
	70.635				0.02	2.20							
		Average Velocity		5.39		5.39			4.50		3.57		3.12

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 9 Bed Slope= 0.00546 Temp= 72 F Rock size= 1 in. Side slope 2:1
Q=50 cfs Water Surface Slope= 0.00498 Thickness= 2 in.

		Location Y=6.0'			Location Y=4.0'			Location Y=3.4'		Location Y=2.6'		Location Y=1.7'	
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec
	72.143	1.74	1.00		1.60		72.143	1.38		0.96		0.57	
X=120'	71.969	1.57	0.90	6.87	1.42	6.59	71.974	1.22	5.74	0.79	4.79	0.40	3.26
	71.620	1.22	0.70	6.61	1.08	6.51	71.667	0.91	5.45	0.49	3.97	0.09	2.01
	71.271	0.87	0.50	6.14	0.73	6.01	71.361	0.60	4.93	0.18	2.88		
	71.097	0.70	0.40	5.71	0.55	5.48	71.054	0.30	4.03				
	70.922	0.52	0.30	5.13	0.38	5.10	70.747	0.02	2.32				
	70.748	0.35	0.20	4.76	0.20	3.88	71.196			0.02	1.94		
	70.661	0.26	0.15	3.84	0.12	3.38	71.590					0.02	1.16
	70.573	0.17	0.10	3.55	0.03	2.37							
	70.486	0.09	0.05	2.32									
	70.437	0.04		1.55									
	70.399	0.00	0.00										
	70.560				0.02	2.01							
		Average Velocity		5.57		5.59			4.73		3.75		2.62
	72.142	1.68	1.00		1.58		72.142	1.45		0.96		0.55	
X=130'	71.977	1.51	0.90	6.73	1.41	6.53	71.981	1.29	5.50	0.80	4.63	0.39	3.51
	71.641	1.18	0.70	6.40	1.08	6.38	71.685	0.98	5.25	0.48	3.88	0.08	2.17
	71.305	0.84	0.50	6.30	0.74	6.00	71.349	0.66	4.98	0.17	3.28		
	71.137	0.67	0.40	5.60	0.57	5.53	71.033	0.34	4.85				
	70.969	0.50	0.30	5.23	0.40	4.82	70.717	0.03	4.10				
	70.801	0.34	0.20	4.83	0.24	4.03	70.706	0.02	1.55				
	70.717	0.25	0.15	4.20	0.15	3.81	71.200			0.02	0.00		
	70.633	0.17	0.10	3.93	0.07	3.18	71.605					0.02	1.64
	70.549	0.08	0.05	3.66									
	70.465	0.00	0.00										
	70.450			2.64									
	70.580				0.02	2.46							
		Average Velocity		5.64		5.51			4.97		3.62		2.88
	72.156	1.64	1.00		1.57		72.158	1.35		1.04		0.60	
X=140'	72.010	1.49	0.90	6.75	1.43	6.34	72.022	1.22	5.40	0.90	4.59	0.44	4.20
	71.679	1.16	0.70	6.48	1.10	6.24	71.722	0.92	5.17	0.60	4.01	0.12	3.28
	71.347	0.83	0.50	5.85	0.76	5.74	71.420	0.62	4.96	0.30	3.15		
	71.181	0.66	0.40	5.31	0.60	5.46	71.119	0.32	4.24				
	71.015	0.50	0.30	4.71	0.43	4.83	70.820	0.02	2.69				
	70.850	0.33	0.20	4.65	0.27	4.18	71.135			0.02	0.00		
	70.767	0.25	0.15	4.08	0.18	3.61	71.558					0.02	1.27
	70.684	0.17	0.10	3.84	0.10	3.06							
	70.601	0.08	0.05	3.55	0.02	2.01							
	70.518	0.00	0.00										
	70.472			2.84									
	70.600				0.02	2.01							
		Average Velocity		5.46		5.31			4.64		3.31		3.52

Run # 10
Q=60 cfs

Bed Slope= 0.00546
Water Surface Slope= 0.00526

Temp= 72 F

Rock size= 1 in.
Thickness= 2 in.

Side slope 2:1

		Location Y=6.0'			Location Y=4.0'			Location Y=3.3'		Location Y=2.6'		Location Y=2.0'	
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec
	72.138	1.72	1.00		1.59		72.138	1.37		1.03		0.63	
X=120'	71.982	1.57	0.90	6.73	1.43	6.49	71.958	1.19	5.65	0.84	4.72	0.45	3.44
	71.634	1.22	0.70	6.39	1.08	6.14	71.663	0.89	5.53	0.55	4.13	0.16	2.20
	71.286	0.87	0.50	5.91	0.74	5.95	71.369	0.60	4.85	0.26	3.18		
	71.111	0.70	0.40	5.49	0.56	5.52	71.074	0.30	4.03				
	70.937	0.52	0.30	4.98	0.39	5.08	70.787	0.02	1.43				
	70.763	0.35	0.20	4.26	0.21	4.44	71.129			0.02	1.16		
	70.676	0.26	0.15	4.07	0.13	3.76	71.521					0.02	0.52
	70.589	0.17	0.10	3.55	0.04	2.57							
	70.502	0.09	0.05	2.64									
	70.443	0.03		2.01									
	70.415	0.00	0.00	2.01									
	70.567				0.02	2.32							
		Average Velocity		5.41		5.53			4.61		3.67		2.60
	72.102	1.63	1.00		1.64		72.102	1.34		0.98		0.72	
X=130'	71.940	1.47	0.90	6.81	1.47	6.55	71.949	1.18	5.71	0.83	4.65	0.57	3.51
	71.613	1.14	0.70	6.75	1.15	6.47	71.657	0.89	5.48	0.54	4.29	0.28	2.64
	71.286	0.82	0.50	6.13	0.82	6.04	71.365	0.60	4.86	0.25	3.32		
	71.122	0.65	0.40	5.85	0.66	5.77	71.072	0.31	4.30				
	70.959	0.49	0.30	5.10	0.49	5.40	70.782	0.02	1.55				
	70.796	0.33	0.20	4.83	0.33	4.63	71.135			0.02	1.04		
	70.713	0.24	0.15	4.40	0.25	3.93	71.395					0.02	0.00
	70.632	0.16	0.10	4.10	0.17	3.32							
	70.550	0.08	0.05	3.06	0.08	1.55							
	70.468	0.00	0.00										
	70.442			2.01									
	70.482				0.02	0.00							
		Average Velocity		5.69		5.40			4.66		3.70		2.46
	72.113	1.80	1.00		1.56		72.113			0.89			
X=140'	71.971	1.54	0.90	6.85	1.42	6.34	71.945			0.72	4.78		
	71.629	1.20	0.70	6.77	1.08	6.13	71.649			0.43	4.38		
	71.287	0.86	0.50	6.12	0.73	5.96	71.353			0.13	3.54		
	71.115	0.68	0.40	5.81	0.56	5.74	71.240			0.02	3.09		
	70.944	0.51	0.30	5.05	0.39	4.98							
	70.773	0.34	0.20	4.47	0.22	4.49							
	70.688	0.26	0.15	4.33	0.13	3.76							
	70.602	0.17	0.10	3.90	0.05	2.79							
	70.517	0.09	0.05	3.15									
	70.480	0.05		2.64									
	70.431	0.00	0.00										
	70.570				0.02	2.32							
		Average Velocity		5.85		5.49					4.19		

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Run # 11
Q=50 cfs

Bed Slope= 0.00500
Water Surface Slope= 0.00292

Temp= 73 F

Rock size= 1 in.
Thickness= 2 in.

Side slope 2:1

		Location Y=6.0'			Location Y=4.0'		Location Y=3.2'		Location Y=2.3'		Location Y=1.4'	
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec
	72.159	1.70	1.00		1.63		1.37		0.87		0.46	
X=120'	72.014	1.55	0.90	6.67	1.49	6.46	1.22	5.46	0.72	4.33	0.31	3.11
	71.842	1.38	0.80		1.32		1.05	5.28	0.55	4.11	0.14	2.59
	71.669	1.21	0.70	6.45	1.14	6.45	0.87	5.26	0.38	3.66		
	71.497	1.04	0.60		0.97		0.70	5.05	0.20	3.28		
	71.324	0.86	0.50	6.06	0.80	6.24	0.53	5.12	0.03	1.84		
	71.151	0.69	0.40	5.62	0.63	6.02	0.36	4.78				
	70.979	0.52	0.30	4.94	0.45	5.74	0.18	4.13				
	70.806	0.34	0.20	4.63	0.28	5.05						
	70.720	0.26	0.15	4.11	0.20	4.89						
	70.634	0.17	0.10	3.85	0.11	3.93						
	70.547	0.09	0.05	3.06	0.02	2.96						
	70.461	0.00	0.00									
	70.456			1.87								
	Bottom				0.02	2.74	0.02	1.87	0.02	1.64	0.02	0.00
		Average Velocity		5.40		5.80		4.79		3.59		2.41
	72.188	1.79	1.00		1.66		1.34		0.85		0.42	
X=130'	72.005	1.61	0.90	6.55	1.48	6.28	1.15	5.25	0.66	3.70	0.23	2.77
	71.826	1.43	0.80		1.30		0.97	5.05	0.48	3.68	0.05	2.32
	71.647	1.25	0.70	6.41	1.12	6.17	0.79	4.72	0.31	3.26		
	71.468	1.07	0.60		0.94		0.62	4.60	0.13	2.43		
	71.289	0.89	0.50	5.83	0.76	5.79	0.44	4.24				
	71.110	0.72	0.40	5.40	0.59	5.37	0.26	3.83				
	70.931	0.54	0.30	4.86	0.41	4.75	0.08	2.74				
	70.752	0.36	0.20	4.49	0.23	3.76						
	70.663	0.27	0.15	4.01	0.14	3.22						
	70.573	0.18	0.10	2.98	0.05	2.59						
	70.484	0.09	0.05	2.88								
	70.394	0.00	0.00									
	70.422			0.00								
	Bottom				0.02	2.07	0.02	1.87	0.02	1.72	0.02	1.69
		Average Velocity		5.31		5.32		4.38		3.20		2.53
	72.197	1.74	1.00		1.62				0.90		0.48	
X=140'	72.030	1.58	0.90	6.41	1.46	6.13			0.73	4.21	0.32	2.93
	71.855	1.40	0.80		1.28				0.56	3.84	0.14	2.59
	71.679	1.23	0.70	6.24	1.10	6.13			0.38	3.28		
	71.504	1.05	0.60		0.93				0.21	3.11		
	71.329	0.88	0.50	5.74	0.75	5.56			0.03	1.94		
	71.154	0.70	0.40	5.18	0.58	5.26						
	70.979	0.53	0.30	4.78	0.40	4.78						
	70.803	0.35	0.20	4.46	0.23	4.10						
	70.716	0.26	0.15	4.01	0.14	4.01						
	70.628	0.17	0.10	3.70	0.05	3.38						
	70.541	0.09	0.05	3.51								
	70.453	0.00	0.00									
	70.445			1.72								
	Bottom				0.02	2.84			0.02	0.00	0.02	2.01
		Average Velocity		5.29		5.83				3.39		2.84

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Run # 12 — Q=20 cfs — Bed Slope= 0.00789 — Water Surface Slope= 0.00491 — Temp= 72 F — Rock size= 1 in. — Thickness= 2 in. — Side slope 2:1

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Fraction of Depth	Velocity ft/sec	Location Y=4.0' Depth Z, ft	Velocity ft/sec	Location Y=3.5' Depth Z, ft	Velocity ft/sec	Location Y=3.0' Depth Z, ft	Velocity ft/sec	Location Y=2.7' Depth Z, ft	Velocity ft/sec
	71.386	0.89	1.00		0.79		0.66		0.46		0.26	
X=120'	71.297	0.80	0.90	5.71	0.70	4.75	0.57	3.91	0.37	3.34	0.17	2.82
	71.208	0.71	0.80		0.61		0.48	3.81	0.28	3.02	0.08	2.35
	71.119	0.62	0.70	5.41	0.52	4.59	0.39	3.55	0.19	2.74		
	71.030	0.53	0.60		0.43		0.30	3.32	0.11	2.41		
	70.942	0.44	0.50	4.53	0.34	3.98	0.21	3.13	0.02	1.98		
	70.853	0.36	0.40	4.35	0.26	3.72	0.13	2.79				
	70.764	0.27	0.30	4.23	0.17	3.44	0.04	2.26				
	70.675	0.18	0.20	4.14	0.08	2.93						
	70.630	0.13	0.15	3.91	0.03	2.87						
	70.586	0.09	0.10	3.54								
	70.541	0.04	0.05	3.34								
	70.532	0.04	0.04	3.23								
	70.497	0.00	0.00									
	Bottom				0.02	2.54	0.02	1.94	0.02	1.87	0.02	1.87
		Average Velocity		4.63		4.00		3.27		2.77		2.45
	71.427	0.96	1.00		0.85		0.72		0.39		0.28	
X=130'	71.331	0.86	0.90	5.57	0.75	4.35	0.62	3.77	0.30	3.28	0.19	2.11
	71.236	0.77	0.80		0.66		0.53	3.63	0.20	2.98	0.09	1.76
	71.140	0.67	0.70	5.20	0.56	4.14	0.43	3.42	0.11	2.74		
	71.045	0.57	0.60		0.47		0.34	3.34				
	70.949	0.48	0.50	4.71	0.37	3.86	0.24	2.87				
	70.853	0.38	0.40	4.43	0.27	3.63	0.14	2.20				
	70.758	0.29	0.30	4.08	0.18	3.23	0.05	1.72				
	70.662	0.19	0.20	3.83	0.08	2.87						
	70.614	0.14	0.15	3.55	0.03	2.48						
	70.567	0.10	0.10	3.05								
	70.519	0.05	0.05	2.93								
	70.471	0.00	0.00									
	70.451			2.07								
	Bottom				0.02	1.64	0.02	1.47	0.02	2.01	0.02	1.14
		Average Velocity		4.48		3.70		3.02		2.84		1 79
	71.493	1.03	1.00		0.79		0.76		0.54		0.25	
X=140'	71.390	0.93	0.90	5.27	0.69	4.43	0.66	3.76	0.43	3.42	0.15	2.29
	71.286	0.83	0.80		0.59		0.56	3.54	0.33	3.00	0.05	1.98
	71.183	0.72	0.70	4.98	0.48	4.36	0.45	3.44	0.23	2.87		
	71.080	0.62	0.60		0.38		0.35	3.28	0.12	2.26		
	70.977	0.52	0.50	4.63	0.28	3.76	0.25	3.06	0.02	1.84		
	70.873	0.41	0.40	4.33	0.17	3.66	0.14	2.88				
	70.770	0.31	0.30	4.11	0.07	3.30	0.04	2.52				
	70.667	0.21	0.20	3.93								
	70.615	0.16	0.15	3.57								
	70.563	0.10	0.10	3.19								
	70.512	0.05	0.05	2.54								
	70.460	0.01	0.01	1.72								
	70.460	0.00	0.00									
	Bottom				0.02	3.02	0.02	1.94	0.02	1.64	0.02	1.84
		Average Velocity		4.36		3.96		3.22		2.77		2.10

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Run # 13 Bed Slope= 0.00087 Temp= 72 F Rock size= 1 in. Side slope 2:1
Q=20 cfs Water Surface Slope= 0.00084 Thickness= 2 in.

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Fraction of Depth	Velocity ft/sec	Location Y=4.0' Depth Z, ft	Velocity ft/sec	Location Y=3.5' Depth Z, ft	Velocity ft/sec	Location Y=3.2' Depth Z, ft	Velocity ft/sec	Location Y=2.8' Depth Z, ft	Velocity ft/sec
	71.343	0.84	1.00		0.78		0.64		0.51		0.28	
X=120'	71.265	0.76	0.90	6.22	0.70	5.12	0.56	4.49	0.43	3.84	0.20	2.96
	71.181	0.67	0.80	6.08	0.62	4.94	0.48	4.10	0.34	3.66	0.12	2.67
	71.097	0.59	0.70	5.88	0.53	4.78	0.39	3.93	0.26	3.11	0.03	1.94
	71.013	0.51	0.60	5.55	0.45	4.56	0.31	3.66	0.18	2.88		
	70.929	0.42	0.50	5.12	0.36	4.33	0.23	3.48	0.09	2.43		
	70.844	0.34	0.40	4.80	0.28	4.10	0.14	3.18				
	70.760	0.25	0.30	4.52	0.20	3.79	0.06	2.91				
	70.676	0.17	0.20	4.21	0.11	3.38						
	70.634	0.13	0.15	3.97	0.07	3.18						
	70.592	0.08	0.10	3.42	0.03	2.72						
	70.550	0.04	0.05	2.88								
	70.508	0.00	0.00									
	70.481			2.07								
	Bottom				0.02	2.67	0.02	2.43	0.02	1.94	0.02	1.64
		Average Velocity		4.95		4.24		3.65		3.08		2.53
	71.346	0.92	1.00		0.80		0.66		0.51		0.26	
X=130'	71.252	0.82	0.90	6.15	0.71	4.93	0.57	4.41	0.41	3.84	0.16	2.79
	71.162	0.73	0.80	5.93	0.62	4.72	0.48	4.38	0.32	3.57	0.07	2.43
	71.073	0.64	0.70	5.77	0.53	4.68	0.39	4.14	0.23	3.34		
	70.983	0.55	0.60	5.51	0.44	4.49	0.30	3.77	0.14	2.79		
	70.894	0.46	0.50	5.05	0.35	4.38	0.21	3.54	0.06	2.20		
	70.804	0.37	0.40	5.00	0.26	3.90	0.12	3.05				
	70.715	0.29	0.30	4.63	0.17	3.44	0.03	2.41				
	70.625	0.20	0.20	4.01	0.08	2.84						
	70.580	0.15	0.15	3.76	0.04	2.17						
	70.536	0.11	0.10	3.32								
	70.491	0.06	0.05	3.02								
	70.480	0.03	0.04	2.84								
	70.446	0.00	0.00									
	Bottom				0.02	1.84	0.02	1.79	0.02	1.64	0.02	2.07
		Average Velocity		4.91		4.08		3.71		3.13		2.50
	71.348	0.90	1.00		0.77		0.65		0.52		0.28	
X=140'	71.280	0.81	0.90	6.06	0.69	5.14	0.56	4.36	0.43	4.01	0.19	2.64
	71.189	0.72	0.80	5.79	0.59	4.98	0.47	4.29	0.34	3.84	0.10	2.32
	71.079	0.63	0.70	5.67	0.50	4.88	0.38	4.01	0.25	3.28		
	70.988	0.54	0.60	5.43	0.41	4.63	0.29	3.78	0.16	2.59		
	70.898	0.45	0.50	5.18	0.32	4.10	0.20	3.47	0.07	2.17		
	70.808	0.36	0.40	4.94	0.23	4.01	0.11	2.96				
	70.717	0.27	0.30	4.41	0.14	3.66	0.02	2.32				
	70.627	0.18	0.20	4.10	0.05	3.06						
	70.582	0.14	0.15	3.66								
	70.536	0.09	0.10	3.36								
	70.491	0.05	0.05	2.46								
	70.451	0.01	0.01	1.55								
	70.446	0.00	0.00									
	Bottom				0.02	2.32	0.02	1.79	0.02	1.72	0.02	1.64
		Average Velocity		4.84		4.29		3.66		3.14		2.28

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 14 Bed Slope= 0.00993 Temp= 72 F Rock size= 1 in. Side slope 2:1
Q=20 cfs Water Surface Slope= 0.00945 Thickness= 2 in.

		Location Y=6.0'			Location Y=4.0'		Location Y=3.6'		Location Y=3.2'		Location Y=2.8'	
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec
	71.317	0.80	1.00		0.79		0.67		0.48		0.27	
X=120'	71.230	0.71	0.90	6.40	0.70	5.36	0.58	4.55	0.40	3.84	0.18	3.28
	71.151	0.63	0.80	6.19	0.62	5.10	0.50	4.32	0.32	3.47	0.10	2.96
	71.073	0.55	0.70	6.13	0.54	5.05	0.42	4.08	0.24	3.32	0.03	2.43
	70.994	0.47	0.60	5.74	0.47	4.83	0.34	3.91	0.16	2.98		
	70.915	0.39	0.50	5.31	0.39	4.75	0.27	3.65	0.08	2.32		
	70.836	0.31	0.40	5.25	0.31	4.36	0.19	3.46				
	70.757	0.24	0.30	5.01	0.23	4.14	0.11	2.93				
	70.679	0.16	0.20	4.59	0.15	3.66	0.03	2.01				
	70.639	0.12	0.15	4.16	0.11	3.38						
	70.600	0.08	0.10	3.91	0.07	2.96						
	70.560	0.04	0.05	3.44	0.03	2.32						
	70.521	0.00	0.00									
	70.505			2.37								
	Bottom				0.02	2.01	0.02	1.84	0.02	2.01	0.02	2.32
		Average Velocity		5.25		4.39		3.68		3.11		2.90
	71.333	0.86	1.00		0.75		0.65		0.49		0.31	
X=130'	71.246	0.78	0.90	6.41	0.66	5.12	0.56	4.49	0.41	3.72	0.22	3.02
	71.159	0.69	0.80	6.17	0.58	4.90	0.47	4.13	0.32	3.59	0.13	2.79
	71.073	0.60	0.70	5.87	0.49	4.94	0.39	3.84	0.23	3.11	0.05	2.43
	70.987	0.52	0.60	5.46	0.40	4.76	0.30	3.55	0.15	2.88		
	70.901	0.43	0.50	5.36	0.32	4.56	0.21	3.40	0.06	2.26		
	70.814	0.34	0.40	5.17	0.23	4.33	0.13	2.98				
	70.728	0.26	0.30	5.04	0.14	3.84	0.04	2.57				
	70.642	0.17	0.20	4.62	0.06	3.22						
	70.598	0.13	0.15	4.18								
	70.555	0.09	0.10	3.74								
	70.512	0.04	0.05	3.15								
	70.469	0.00	0.00									
	70.438			1.37								
	Bottom				0.02	2.77	0.02	2.37	0.02	1.79	0.02	1.55
		Average Velocity		5.16		4.43		3.59		3.07		2.65
	71.323	0.92	1.00		0.78		0.70		0.52		0.32	
X=140'	71.223	0.82	0.90	6.24	0.68	5.21	0.60	4.57	0.42	4.08	0.22	3.19
	71.132	0.73	0.80	6.02	0.59	5.18	0.51	4.26	0.33	3.81	0.13	2.93
	71.041	0.64	0.70	5.81	0.49	4.98	0.42	4.01	0.24	3.38	0.04	1.94
	70.950	0.55	0.60	5.33	0.40	4.78	0.32	3.63	0.15	2.67		
	70.859	0.45	0.50	5.27	0.31	4.56	0.23	3.54	0.06	1.47		
	70.768	0.36	0.40	4.74	0.22	4.18	0.14	3.13				
	70.677	0.27	0.30	4.30	0.13	3.47	0.05	2.11				
	70.586	0.18	0.20	3.74	0.04	2.67						
	70.541	0.14	0.15	3.51								
	70.495	0.09	0.10	2.79								
	70.450	0.05	0.05	2.07								
	70.404	0.00	0.00									
	70.438			1.94								
	Bottom				0.02	2.43	0.02	1.87	0.02	0.90	0.02	1.87
		Average Velocity		4.81		4.42		3.84		3.10		2.74

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 15
Q=20 cfs

Bed Slope= 0.01087
Water Surface Slope= 0.01074

Temp= 71 F

Rock size= 1 in.
Thickness= 2 in.

Side slope 2:1

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Fraction of Depth	Velocity ft/sec	Location Y=4.0' Depth Z, ft	Velocity ft/sec	Location Y=3.6' Depth Z, ft	Velocity ft/sec	Location Y=3.2' Depth Z, ft	Velocity ft/sec	Location Y=2.7' Depth Z, ft	Velocity ft/sec
	71.302	0.86	1.00		0.77		0.65		0.42		0.21	
X=120'	71.198	0.75	0.90	6.77	0.66	5.55	0.54	4.69	0.32	4.26	0.10	2.98
	71.114	0.67	0.80	6.51	0.58	5.40	0.46	4.49	0.23	3.84	0.02	2.14
	71.031	0.59	0.70	6.29	0.49	5.25	0.38	4.01	0.15	3.47		
	70.947	0.50	0.60	6.05	0.41	5.05	0.29	3.84	0.07	3.18		
	70.864	0.42	0.50	5.92	0.33	4.55	0.21	3.54				
	70.780	0.33	0.40	5.63	0.24	4.40	0.12	3.02				
	70.697	0.25	0.30	4.84	0.16	4.08	0.04	2.07				
	70.613	0.17	0.20	4.32	0.08	3.42						
	70.571	0.13	0.15	4.11	0.03	2.93						
	70.530	0.08	0.10	3.86								
	70.488	0.04	0.05	3.36								
	70.446	0.00	0.00									
	Bottom				0.02	2.93	0.02	1.37	0.02	2.84	0.02	2.05
		Average Velocity		5.47		4.65		3.72		3.66		2.64
	71.314	0.84	1.00		0.79		0.56		0.47		0.21	
X=130'	71.224	0.75	0.90	6.49	0.70	5.37	0.47	4.74	0.38	4.26	0.12	2.84
	71.140	0.67	0.80	6.38	0.62	5.31	0.39	4.41	0.30	3.91	0.03	2.43
	71.057	0.58	0.70	6.17	0.53	5.25	0.30	4.26	0.22	3.76		
	70.974	0.50	0.60	6.03	0.45	5.05	0.22	4.01	0.13	3.02		
	70.891	0.42	0.50	5.55	0.37	4.57	0.14	3.47	0.05	2.07		
	70.807	0.33	0.40	5.41	0.28	4.40	0.05	3.23				
	70.724	0.25	0.30	4.97	0.20	4.18						
	70.641	0.17	0.20	4.62	0.12	3.76						
	70.599	0.13	0.15	4.40	0.07	3.32						
	70.557	0.08	0.10	4.11	0.03	2.48						
	70.516	0.04	0.05	3.68								
	70.474	0.00	0.00									
	70.445	0.02	0.02	2.64								
	Bottom				0.02	2.32	0.02	2.84	0.02	1.55	0.02	1.47
		Average Velocity		5.39		4.54		4.00		3.40		2.52
	71.324	0.84	1.00		0.76		0.69		0.41		0.29	
X=140'	71.238	0.75	0.90	6.30	0.68	5.46	0.60	4.83	0.32	4.38	0.20	3.02
	71.154	0.67	0.80	6.24	0.59	5.43	0.52	4.50	0.24	4.03	0.12	2.88
	71.071	0.58	0.70	5.96	0.51	5.31	0.44	4.14	0.15	3.77	0.04	2.26
	70.987	0.50	0.60	5.91	0.43	5.06	0.35	3.91	0.07	3.40		
	70.904	0.42	0.50	5.62	0.34	4.65	0.27	3.72				
	70.820	0.33	0.40	5.20	0.26	4.53	0.19	3.28				
	70.737	0.25	0.30	4.91	0.18	4.23	0.10	2.74				
	70.653	0.17	0.20	4.32	0.09	3.72	0.02	2.28				
	70.611	0.13	0.15	3.91	0.05	3.44						
	70.570	0.08	0.10	3.44								
	70.528	0.04	0.05	2.93								
	70.514	0.03	0.03	2.57								
	70.486	0.00	0.00									
	Bottom				0.02	3.07	0.02	2.32	0.02	2.74	0.02	1.04
		Average Velocity		5.18		4.89		3.77		3.79		2.64

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 16 Bed Slope= 0.00700 Temp= 71 F Rock size= 1 in. Side slope 2:1
Q=30 cfs Water Surface Slope= 0.00685 Thickness= 2 in.

		Location Y=6.0'			Location Y=4.0'		Location Y=3.6'		Location Y=3.2'		Location Y=2.8'		Location Y=2.4'	
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec
	71.687	1.22	1.00		1.15		1.05		0.85		0.63		0.45	
X=120'	71.564	1.10	0.90	6.44	-1.02	5.62	0.93	4.98	0.73	4.43	0.51	4.08	0.32	3.32
	71.442	0.98	0.80	6.28	0.90	5.57	0.81	4.83	0.61	4.14	0.39	3.79	0.20	2.88
	71.319	0.86	0.70	6.01	0.78	5.40	0.68	4.72	0.48	3.88	0.27	3.55	0.08	2.23
	71.197	0.73	0.60	5.81	0.66	5.40	0.56	4.43	0.36	3.40	0.15	2.72		
	71.075	0.61	0.50	5.33	0.54	5.25	0.44	4.21	0.24	3.22	0.02	1.43		
	70.953	0.49	0.40	4.90	0.41	4.78	0.32	4.13	0.12	2.46				
	70.831	0.37	0.30	4.76	0.29	4.41	0.20	3.47						
	70.708	0.24	0.20	4.14	0.17	3.77	0.07	2.77						
	70.647	0.18	0.15	3.65	0.11	3.57								
	70.586	0.12	0.10	2.88	0.05	2.96								
	70.525	0.06	0.05	2.01										
	70.492	0.03	0.02	1.94										
	70.464	0.00	0.00											
	Bottom				0.02	2.79	0.02	1.84	0.02	1.84	0.02	1.16	0.02	1.43
		Average Velocity		5.04		4.85		4.18		3.51		3.29		2.74
	71.683	1.27	1.00		1.10		1.01		0.77		0.65		0.45	
X=130'	71.550	1.13	0.90	6.41	0.96	5.46	0.88	4.91	0.63	4.33	0.51	4.10	0.32	3.28
	71.424	1.01	0.80	6.39	0.84	5.25	0.75	4.71	0.51	4.01	0.39	3.84	0.19	2.96
	71.298	0.88	0.70	6.04	0.71	5.18	0.63	4.49	0.38	3.78	0.26	3.38	0.07	2.46
	71.173	0.75	0.60	5.85	0.59	5.13	0.50	4.26	0.26	3.38	0.14	2.72		
	71.047	0.63	0.50	5.38	0.46	4.91	0.37	4.10	0.13	2.67				
	70.921	0.50	0.40	4.85	0.34	4.63	0.25	3.68						
	70.795	0.38	0.30	4.78	0.21	4.26	0.12	3.09						
	70.670	0.25	0.20	3.91	0.09	3.63								
	70.607	0.19	0.15	3.57	0.02	3.23								
	70.544	0.13	0.10	3.28										
	70.481	0.06	0.05	3.06										
	70.444	0.03	0.02	1.98										
	70.418	0.00	0.00											
	Bottom				0.02	2.91	0.02	2.05	0.02	2.05	0.02	1.47	0.02	1.64
		Average Velocity		5.10		4.78		4.08		3.53		3.32		2.85
	71.689	1.14	1.00		1.08		1.04		0.85		0.64		0.42	
X=140'	71.561	1.03	0.90	6.59	0.97	5.52	0.93	4.98	0.75	4.76	0.54	4.33	0.32	3.32
	71.446	0.92	0.80	6.29	0.86	5.47	0.82	4.89	0.63	4.65	0.42	4.24	0.20	3.11
	71.332	0.80	0.70	6.19	0.74	5.41	0.70	4.88	0.52	4.13	0.31	3.46	0.09	2.52
	71.217	0.68	0.60	5.93	0.63	5.38	0.59	4.63	0.40	3.77	0.19	3.28		
	71.102	0.57	0.50	5.67	0.51	5.31	0.47	4.55	0.29	3.28	0.08	2.46		
	70.987	0.46	0.40	5.31	0.40	5.12	0.36	4.01	0.17	3.06				
	70.872	0.34	0.30	4.92	0.28	4.71	0.24	3.55	0.06	2.23				
	70.758	0.23	0.20	4.78	0.17	4.41	0.13	2.96						
	70.700	0.17	0.15	4.41	0.11	3.79	0.07	2.67						
	70.643	0.11	0.10	4.10	0.05	3.28								
	70.585	0.06	0.05	3.28										
	70.528	0.00	0.00											
	70.512			2.84										
	Bottom				0.02	2.84	0.02	2.01	0.02	1.72	0.02	0.90	0.02	1.43
		Average Velocity		5.39		4.95		4.18		3.73		3.46		2.83

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 17 Bed Slope= 0.00797 Temp= 71 F Rock size= 1 in. Side slope 2:1
Q=30 cfs Water Surface Slope= 0.00723 Thickness= 2 in.

		Location Y=6.0'			Location Y=4.0'		Location Y=3.6'		Location Y=3.2'		Location Y=2.8'		Location Y=2.4'	
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec
	71.639	1.11	1.00		1.08		0.95		0.82		0.59		0.41	
X=120'	71.526	1.00	0.90	6.75	0.97	6.02	0.84	5.23	0.71	4.57	0.48	4.40	0.30	3.66
	71.415	0.89	0.80	6.54	0.86	5.79	0.73	5.21	0.60	4.40	0.37	3.95	0.19	3.19
	71.304	0.78	0.70	6.34	0.75	5.69	0.62	5.13	0.49	4.01	0.26	3.47	0.07	2.54
	71.193	0.67	0.60	6.15	0.64	5.87	0.51	4.86	0.38	3.91	0.14	2.98		
	71.082	0.55	0.50	5.78	0.53	5.56	0.39	4.63	0.26	3.28	0.03	2.20		
	70.971	0.44	0.40	5.36	0.42	5.27	0.28	4.24	0.15	2.96				
	70.860	0.33	0.30	4.90	0.30	4.69	0.17	3.81	0.04	2.01				
	70.749	0.22	0.20	4.69	0.19	4.27	0.06	3.47						
	70.694	0.17	0.15	4.32	0.14	3.72								
	70.638	0.11	0.10	4.14	0.08	3.44								
	70.583	0.06	0.05	3.51										
	70.527	0.00	0.00											
	70.453			2.88										
	Bottom				0.02	2.64	0.02	3.06	0.02	1.94	0.02	1.55	0.02	1.87
		Average Velocity		5.50		5.10		4.56		3.66		3.49		3.07
	71.646	1.14	1.00		1.09		0.97		0.84		0.67		0.39	
X=130'	71.541	1.04	0.90	6.75	0.98	5.60	0.86	5.23	0.73	4.57	0.56	4.13	0.29	3.66
	71.425	0.92	0.80	6.40	0.87	5.56	0.74	5.10	0.62	4.40	0.45	4.11	0.17	3.26
	71.310	0.81	0.70	6.08	0.75	5.56	0.63	4.90	0.50	4.01	0.33	3.32	0.06	2.32
	71.194	0.69	0.60	6.00	0.63	5.43	0.51	4.78	0.39	3.63	0.22	2.88	0.02	1.79
	71.074	0.57	0.50	5.64	0.51	5.05	0.39	4.40	0.27	3.28	0.10	2.01		
	70.984	0.46	0.40	5.23	0.40	4.93	0.28	4.13	0.16	2.64				
	70.848	0.35	0.30	4.86	0.29	4.41	0.17	3.55	0.04	2.01				
	70.733	0.23	0.20	4.43	0.17	3.93	0.05	3.28						
	70.675	0.17	0.15	4.20	0.12	3.34								
	70.617	0.12	0.10	3.66	0.06	3.11								
	70.560	0.06	0.05	3.30										
	70.502	0.00	0.00											
	70.451			1.64										
	Bottom				0.02	2.37	0.02	2.26	0.02	1.27	0.02	1.37		
		Average Velocity		5.32		4.82		4.41		3.56		3.20		3.07
	71.635	1.19	1.00		1.10		0.98		0.82		0.62		0.41	
X=140'	71.510	1.07	0.90	6.53	0.98	5.92	0.85	5.26	0.70	4.49	0.49	4.33	0.28	3.66
	71.391	0.95	0.80	6.47	0.86	5.81	0.74	5.17	0.58	4.33	0.38	4.16	0.16	3.23
	71.273	0.83	0.70	6.15	0.74	5.72	0.62	4.78	0.46	4.16	0.26	3.47	0.05	2.07
	71.154	0.71	0.60	5.87	0.62	5.58	0.50	4.49	0.34	3.74	0.14	3.00		
	71.036	0.59	0.50	5.76	0.50	5.21	0.38	4.33	0.22	3.38	0.02	1.92		
	70.917	0.47	0.40	5.10	0.38	4.88	0.26	3.93	0.10	2.84				
	70.798	0.36	0.30	4.66	0.27	4.59	0.14	3.47						
	70.680	0.24	0.20	4.32	0.15	3.95	0.03	2.32						
	70.621	0.18	0.15	3.76	0.09	3.70								
	70.562	0.12	0.10	3.51	0.03	3.06								
	70.502	0.06	0.05	0.73										
	70.443	0.00	0.00											
	70.471	0.02	0.01	0.52										
	Bottom				0.02	2.84	0.02	2.37	0.02	2.01	0.02	1.87	0.02	1.72
		Average Velocity		5.12		5.06		4.34		3.75		3.55		3.07

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 18 — Q=30 cfs — Bed Slope= 0.00896 — Water Surface Slope= 0.00677 — Temp= 71 F — Rock size= 1 in. — Thickness= 2 in. — Side slope 2:1

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Location Y=6.0' Fraction of Depth	Location Y=6.0' Velocity ft/sec	Location Y=4.0' Depth Z, ft	Location Y=4.0' Velocity ft/sec	Location Y=3.6' Depth Z, ft	Location Y=3.6' Velocity ft/sec	Location Y=3.2' Depth Z, ft	Location Y=3.2' Velocity ft/sec	Location Y=2.8' Depth Z, ft	Location Y=2.8' Velocity ft/sec	Location Y=2.4' Depth Z, ft	Location Y=2.4' Velocity ft/sec
	71.607	1.13	1.00		1.03		0.95		0.80		0.59		0.36	
X=120'	71.505	1.03	0.90	6.85	0.93	6.04	0.85	5.26	0.70	4.78	0.49	4.27	0.26	3.70
	71.390	0.92	0.80	6.73	0.81	6.02	0.73	5.26	0.59	4.46	0.37	3.88	0.15	3.11
	71.276	0.80	0.70	6.41	0.70	6.02	0.62	5.04	0.47	4.08	0.26	3.40	0.03	2.26
	71.161	0.69	0.60	6.11	0.58	5.91	0.51	4.86	0.36	3.84	0.15	2.72		
	71.047	0.57	0.50	6.02	0.47	5.62	0.39	4.26	0.24	3.18	0.03	2.14		
	70.933	0.46	0.40	5.56	0.36	5.31	0.28	4.10	0.13	2.64				
	70.818	0.34	0.30	4.69	0.24	4.91	0.16	3.82						
	70.704	0.23	0.20	4.20	0.13	3.93	0.05	2.32						
	70.647	0.17	0.15	3.51	0.07	3.40								
	70.589	0.11	0.10	3.36										
	70.532	0.06	0.05	2.84										
	70.480	0.01	0.01	2.40										
	70.475	0.00	0.00											
					0.02	1.94	0.02	1.72	0.02	1.94	0.02	2.01	0.02	1.64
		Average Velocity		5.39		5.26		4.39		3.70		3.37		3.08
	71.588	1.16	1.00		1.07		0.96		0.78		0.62		0.34	
X=130'	71.479	1.04	0.90	6.95	0.95	5.91	0.84	5.10	0.66	4.57	0.50	4.33	0.22	3.40
	71.388	0.93	0.80	6.81	0.84	5.91	0.73	4.91	0.55	4.11	0.39	4.01	0.11	3.15
	71.248	0.81	0.70	6.55	0.72	5.79	0.61	4.72	0.43	3.76	0.27	3.44	0.02	2.14
	71.132	0.69	0.60	6.24	0.60	5.67	0.50	4.41	0.31	3.28	0.15	2.59		
	71.017	0.58	0.50	5.97	0.49	5.36	0.38	4.18	0.20	2.84	0.04	1.64		
	70.901	0.46	0.40	5.36	0.37	4.86	0.27	4.01	0.08	2.32	0.02	0.73		
	70.785	0.35	0.30	4.89	0.26	4.69	0.15	2.96						
	70.669	0.23	0.20	4.62	0.14	4.40	0.03	2.14						
	70.612	0.17	0.15	3.98	0.08	3.19								
	70.554	0.12	0.10	3.76	0.03	2.32								
	70.496	0.06	0.05	2.84										
	70.438	0.00	0.00											
	70.426			0.90										
	Bottom				0.02	2.32	0.02	2.01	0.02	1.64				
		Average Velocity		5.49		5.10		4.14		3.47		3.31		3.03
	71.616	1.11	1.00		1.12		0.92		0.85		0.65		0.40	
X=140'	71.504	1.00	0.90	6.95	1.01	6.13	0.81	5.37	0.74	4.72	0.54	4.33	0.29	3.47
	71.393	0.89	0.80	6.57	0.90	5.91	0.70	5.26	0.63	4.33	0.43	4.05	0.18	3.06
	71.281	0.78	0.70	6.55	0.79	5.88	0.59	4.83	0.52	3.98	0.32	3.70	0.06	2.32
	71.170	0.67	0.60	6.13	0.67	5.74	0.48	4.78	0.41	3.51	0.21	3.06	0.02	1.72
	71.058	0.56	0.50	5.72	0.56	5.67	0.36	4.41	0.28	3.36	0.10	2.07		
	70.946	0.44	0.40	5.57	0.45	5.38	0.25	4.10	0.18	3.19	0.02	0.00		
	70.837	0.33	0.30	5.20	0.34	4.97	0.14	3.84	0.07	3.06				
	70.725	0.22	0.20	4.66	0.23	4.21	0.03	3.23						
	70.670	0.17	0.15	4.26	0.17	3.84								
	70.614	0.11	0.10	3.91	0.12	3.55								
	70.558	0.06	0.05	3.74	0.06	2.48								
	70.503	0.00	0.00											
	70.502			3.06										
	Bottom				0.02	2.01	0.02	2.62	0.02	0.00				
		Average Velocity		5.58		5.10		4.53		3.63		3.25		2.92

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 19 Bed Slope= 0.00995 Temp= 71 F Rock size= 1 in. Side slope 2:1
Q=30 cfs Water Surface Slope= 0.00796 Thickness= 2 in.

		Location Y=6.0'			Location Y=4.0'		Location Y=3.6'		Location Y=3.2'		Location Y=2.8'		Location Y=2.4'	
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec
	71.544	1.09	1.00		1.00		0.91		0.78		0.56		0.33	
X=120'	71.429	0.98	0.90	7.49	0.89	6.41	0.79	5.63	0.66	5.19	0.45	4.56	0.21	3.63
	71.321	0.87	0.80	7.29	0.78	6.37	0.69	5.38	0.55	5.13	0.34	4.33	0.10	3.11
	71.212	0.76	0.70	6.89	0.67	6.34	0.58	5.33	0.44	4.57	0.23	3.66		
	71.103	0.65	0.60	6.81	0.56	6.06	0.47	5.05	0.33	4.27	0.12	2.84		
	70.995	0.54	0.50	5.91	0.46	5.95	0.36	4.60	0.23	3.77				
	70.886	0.44	0.40	5.67	0.35	5.56	0.25	4.21	0.12	2.84				
	70.777	0.33	0.30	5.31	0.24	4.91	0.14	3.66						
	70.668	0.22	0.20	4.52	0.13	4.72								
	70.614	0.16	0.15	3.93	0.07	3.40								
	70.560	0.11	0.10	3.47	0.02	2.79								
	70.505	0.05	0.05	2.88										
	70.472	0.02	0.02	2.14										
	70.451	-0.00	0.00											
	Bottom				0.02	1.47	0.02	0.00	0.02	1.79	0.02	1.16	0.02	2.14
		Average Velocity		5.79		5.55		4.46		4.14		3.59		3.15

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 20
Q=40 cfs

Bed Slope= 0.00510
Water Surface Slope= 0.00515

Temp= 70 F

Rock size= 1 in.
Thickness= 2 in.

Side slope 2:1

		Location Y=6.0'			Location Y=4.0'		Location Y=3.5'		Location Y=3.0'		Location Y=2.5'		Location Y=2.0'	
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec	Depth Z, ft	Velocity ft/sec
	72.056	1.54	1.00		1.55		1.40		1.13		0.88		0.60	
X=120'	71.868	1.35	0.90	6.17	1.36	5.56	1.21	4.97	0.95	4.30	0.70	3.59	0.42	3.23
	71.718	1.20	0.80	5.97	1.21	5.51	1.06	4.91	0.80	4.05	0.55	3.36	0.27	2.59
	71.568	1.05	0.70	5.79	1.06		0.91	4.83	0.65	3.88	0.40	3.18	0.12	2.01
	71.418	0.90	0.60	5.52	0.91	5.50	0.76	4.44	0.50	3.66	0.25	2.72		
	71.268	0.75	0.50	5.31	0.76	5.30	0.61	4.36	0.35	3.32	0.10	2.01		
	71.119	0.60	0.40	4.91	0.61	5.04	0.46	4.10	0.20	2.64				
	70.969	0.45	0.30	4.63	0.46	4.55	0.31	3.59	0.05	1.27				
	70.819	0.30	0.20	4.41	0.31	4.01	0.16	3.22						
	70.744	0.22	0.15	4.26	0.24	3.66	0.08	1.72						
	70.668	0.15	0.10	3.84	0.16	3.15								
	70.594	0.07	0.05	3.57	0.09	3.02								
	70.535	0.02	0.01	3.06										
	70.519	0.00	0.00											
	Bottom				0.02	1.79	0.02	0.73	0.02	0.00	0.02	1.16	0.02	1.64
	-	Average Velocity		5.02		4.79		4.12		3.42		2.96		2.62
	72.028	1.56	1.00		1.54		1.37		1.10		0.89		0.66	
X=130'	71.884	1.42	0.90	6.15	1.39	5.48	1.23	4.97	0.96	4.26	0.75	4.01	0.52	3.28
	71.726	1.26	0.80	5.97	1.23	5.43	1.07	4.78	0.80	4.01	0.59	3.47	0.36	2.48
	71.569	1.10	0.70	5.81	1.08	5.43	0.91	4.75	0.64	3.93	0.43	3.06	0.20	2.32
	71.412	0.94	0.60	5.63	0.92	5.31	0.76	4.41	0.49	3.66	0.28	2.79	0.05	1.16
	71.255	0.79	0.50	5.53	0.76	5.05	0.60	4.20	0.33	3.47	0.12	1.55		
	71.097	0.63	0.40	4.89	0.60	4.91	0.44	4.08	0.17	3.06				
	70.940	0.47	0.30	4.75	0.45	4.78	0.28	3.68						
	70.783	0.31	0.20	4.18	0.29	4.10	0.13	2.59						
	70.704	0.24	0.15	3.84	0.21	3.53	0.05	1.47						
	70.625	0.16	0.10	3.66	0.13	3.19								
	70.547	0.08	0.05	2.84	0.06	2.37								
	70.477	0.01	0.01	1.16										
	70.468	0.00	0.00											
	Bottom				0.02	1.04	0.02	0.00	0.02	1.16	0.02	1.16	0.02	0.52
		Average Velocity		5.01		4.73		4.05		3.54		2.95		2.43
	71.984	1.48	1.00		1.43		1.31		1.03		0.80		0.53	
X=140'	71.838	1.33	0.90	6.45	1.29	5.91	1.17	5.34	0.89	4.63	0.65	4.18	0.38	3.68
	71.690	1.18	0.80	6.39	1.14	5.81	1.02	5.21	0.74	4.56	0.50	4.10	0.24	3.06
	71.542	1.03	0.70	6.24	0.99	5.79	0.87	5.05	0.59	4.43	0.36	3.51	0.09	2.32
	71.394	0.88	0.60	6.13	0.84	5.67	0.72	4.91	0.44	3.86	0.21	3.23		
	71.247	0.74	0.50	5.79	0.70	5.50	0.57	4.60	0.30	3.59	0.06	1.94		
	71.099	0.59	0.40	5.47	0.55	5.25	0.43	4.49	0.15	2.93				
	70.951	0.44	0.30	5.25	0.40	4.71	0.28	3.59						
	70.803	0.30	0.20	4.63	0.25	4.46	0.13	2.96						
	70.729	0.22	0.15	4.11	0.18	3.65	0.06	1.64						
	70.655	0.15	0.10	3.76	0.10	3.19								
	70.581	0.07	0.05	3.28	0.03	2.74								
	70.507	0.00	0.00											
	70.501	0.02	0.01	1.64										
	Bottom				0.02	2.32	0.02	1.16	0.02	1.64	0.02	1.07	0.02	1.07
		Average Velocity		5.41		5.08		4.38		3.85		3.44		2.95

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 21 Bed Slope= 0.00804 Temp= 70 F Rock size= 1 in. Side slope 2:1
Q=40 cfs Water Surface Slope= 0.00586 Thickness= 2 in.

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Fraction of Depth	Velocity ft/sec	Location Y=4.0' Depth Z, ft	Velocity ft/sec	Location Y=3.5' Depth Z, ft	Velocity ft/sec	Location Y=3.0' Depth Z, ft	Velocity ft/sec	Location Y=2.5' Depth Z, ft	Velocity ft/sec	Location Y=2.0' Depth Z, ft	Velocity ft/sec
	71.967	1.50	1.00		1.44		1.30		1.03		0.78		0.50	
X=120'	71.828	1.36	0.90	6.39	1.30	6.06	1.16	5.00	0.89	4.50	0.64	3.81	0.36	3.00
	71.680	1.22	0.80	6.24	1.15	5.79	1.01	5.00	0.75	4.24	0.49	3.57	0.22	2.84
	71.532	1.07	0.70	6.13	1.00	5.74	0.86	4.72	0.60	3.91	0.34	3.05	0.07	2.20
	71.384	0.92	0.60	5.84	0.85	5.67	0.71	4.59	0.45	3.84	0.19	2.69	0.02	1.72
	71.237	0.77	0.50	5.79	0.71	5.43	0.57	4.49	0.30	3.28	0.05	2.14		
	71.089	0.62	0.40	5.60	0.56	5.26	0.42	4.11	0.15	2.84	0.02	1.64		
	70.941	0.48	0.30	4.86	0.41	4.78	0.27	3.81						
	70.793	0.33	0.20	4.55	0.26	4.01	0.12	3.11						
	70.719	0.25	0.15	4.18	0.19	3.55	0.05	2.74						
	70.645	0.18	0.10	3.55	0.12	3.28								
	70.571	0.11	0.05	2.98	0.04	2.43								
	70.481	0.02	0.01	2.48										
	70.465	0.00	0.00											
	Bottom				0.02	1.64	0.02	2.32	0.02	1.94				
		Average Velocity		5.25		5.03		4.29		3.65		3.11		2.66
	71.943	1.49	1.00		1.45		1.29		1.05		0.74		0.55	
X=130'	71.797	1.35	0.90	6.61	1.30	5.88	1.14	5.21	0.90	4.46	0.60	4.03	0.40	3.38
	71.651	1.20	0.80	6.49	1.15	5.86	1.00	5.08	0.76	4.33	0.45	3.74	0.26	3.02
	71.504	1.06	0.70	6.30	1.01	5.77	0.85	5.00	0.61	4.01	0.31	3.18	0.11	2.80
	71.358	0.91	0.60	6.08	0.86	5.56	0.70	4.83	0.46	3.95	0.16	2.84		
	71.212	0.76	0.50	5.81	0.72	5.46	0.56	4.46	0.32	3.61				
	71.066	0.62	0.40	5.53	0.57	5.10	0.41	4.27	0.17	3.06				
	70.920	0.47	0.30	5.12	0.42	4.88	0.27	3.81	0.03	1.64				
	70.773	0.32	0.20	4.40	0.28	4.24	0.12	2.79						
	70.700	0.25	0.15	4.01	0.20	3.91	0.05	1.72						
	70.627	0.18	0.10	3.66	0.13	3.15								
	70.554	0.11	0.05	3.51	0.06	2.59								
	70.485	0.02	0.01	1.64										
	70.449	0.00	0.00											
	Bottom				0.02	1.79	0.02	1.37	0.02	0.00	0.02	1.64	0.02	0.00
		Average Velocity		5.37		5.00		4.33		3.69		3.27		2.79
	71.911	1.41	1.00		1.37		1.22		0.99		0.70		0.45	
X=140'	71.774	1.27	0.90	6.49	1.23	5.81	1.08	5.41	0.85	4.60	0.56	4.11	0.31	3.59
	71.636	1.13	0.80	6.43	1.10	5.81	0.95	5.28	0.71	4.60	0.42	3.88	0.17	3.11
	71.498	0.99	0.70	6.34	0.96	5.79	0.81	5.08	0.57	4.36	0.29	3.40	0.03	2.54
	71.361	0.86	0.60	6.19	0.82	5.67	0.67	4.85	0.43	3.88	0.15	2.98	0.02	1.87
	71.224	0.72	0.50	6.02	0.68	5.56	0.53	4.66	0.30	3.15	0.02	1.64		
	71.087	0.58	0.40	5.43	0.55	5.37	0.40	4.49	0.16	2.93				
	70.949	0.44	0.30	5.21	0.41	4.68	0.26	3.93	0.02	2.32				
	70.812	0.31	0.20	4.79	0.27	4.00	0.12	3.18						
	70.743	0.24	0.15	4.65	0.20	3.94	0.05	2.37						
	70.674	0.17	0.10	3.84	0.13	3.15								
	70.608	0.10	0.05	3.22	0.07	2.59								
	70.521	0.02	0.01	2.98										
	70.505	0.00	0.00											
	Bottom				0.02	1.27	0.02	1.72	0.02	2.01				
		Average Velocity		5.47		4.96		4.50		3.80		3.39		3.13

Run 8 22 | Bed Slope= 0.00701 | Temp= 70 F | Rock size= 1 in. | Side slope 2:1
Q=40 cfs | Water Surface Slope= 0.00536 | | Thickness= 2 in.

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Location Y=6.0' Fraction of Depth	Location Y=6.0' Velocity ft/sec	Location Y=4.0' Depth Z, ft	Location Y=4.0' Velocity ft/sec	Location Y=3.5' Depth Z, ft	Location Y=3.5' Velocity ft/sec	Location Y=3.0' Depth Z, ft	Location Y=3.0' Velocity ft/sec	Location Y=2.5' Depth Z, ft	Location Y=2.5' Velocity ft/sec	Location Y=2.0' Depth Z, ft	Location Y=2.0' Velocity ft/sec
	71.909	1.46	1.00		1.41		1.22		1.03		0.72		0.46	
X=120'	71.767	1.31	0.90	6.73	1.27	6.19	1.08	5.33	0.89	4.63	0.58	3.84	0.32	3.28
	71.624	1.17	0.80	6.63	1.13	6.17	0.94	5.25	0.74	4.49	0.44	3.66	0.18	2.84
	71.482	1.03	0.70	6.32	0.98	6.04	0.79	4.91	0.60	4.26	0.30	3.19	0.04	1.72
	71.340	0.89	0.60	6.09	0.85	5.91	0.65	4.78	0.46	3.81	0.16	2.84	0.02	1.64
	71.198	0.74	0.50	5.56	0.70	5.77	0.51	4.71	0.32	3.47				
	71.055	0.60	0.40	5.51	0.56	5.53	0.37	4.33	0.17	3.06				
	70.913	0.46	0.30	5.00	0.42	5.23	0.23	3.81	0.03	0.73				
	70.771	0.32	0.20	4.37	0.28	4.40	0.08	2.93						
	70.699	0.25	0.15	3.84	0.20	3.84								
	70.628	0.17	0.10	3.63	0.13	2.93								
	70.557	0.10	0.05	3.02	0.06	2.59								
	70.470	0.02	0.01	1.47										
	70.454	0.00	0.00											
	Bottom				0.02	0.90	0.02	2.43	0.02	0.00	0.02	2.14		
		Average Velocity		5.38		5.22		4.50		3.66		3.26		2.75
	71.908	1.48	1.00		1.37		1.25		0.90		0.77		0.40	
X=130'	71.765	1.33	0.90	6.75	1.22	6.02	1.10	5.41	0.84	4.52	0.63	4.33	0.25	3.44
	71.620	1.19	0.80	6.73	1.08	6.00	0.96	5.18	0.68	4.33	0.48	3.76	0.11	2.93
	71.476	1.04	0.70	6.28	0.93	5.90	0.82	4.90	0.55	4.13	0.34	3.23	0.02	2.07
	71.332	0.90	0.60	6.22	0.79	5.84	0.67	4.83	0.40	3.65	0.19	2.43		
	71.188	0.75	0.50	6.03	0.64	5.64	0.53	4.68	0.26	3.15	0.05	1.64		
	71.043	0.61	0.40	5.65	0.50	5.46	0.38	4.47	0.12	2.79				
	70.899	0.47	0.30	5.31	0.35	4.98	0.24	3.83						
	70.755	0.32	0.20	4.27	0.21	4.18	0.09	2.26						
	70.682	0.25	0.15	4.18	0.14	3.66								
	70.610	0.18	0.10	3.93	0.07	3.06								
	70.538	0.10	0.05	3.02										
	70.450	0.02	0.01	2.01										
	70.434	0.00	0.00											
	Bottom				0.02	2.59	0.02	0.00	0.02	2.14	0.02	1.27		
		Average Velocity		5.53		5.25		4.36		3.71		3.21		3.03
	71.886	1.41	1.00		1.30		1.20		0.88		0.67		0.43	
X=140'	71.749	1.27	0.90	6.90	1.17	6.22	1.06	5.41	0.74	5.01	0.54	4.21	0.29	3.76
	71.611	1.13	0.80	6.89	1.03	6.22	0.92	5.37	0.61	4.49	0.40	3.93	0.16	3.19
	71.474	0.99	0.70	6.53	0.89	6.19	0.78	5.25	0.47	4.14	0.26	3.44		
	71.336	0.86	0.60	6.51	0.75	6.11	0.65	5.12	0.33	3.98	0.12	2.91		
	71.199	0.72	0.50	6.02	0.62	5.71	0.51	4.71	0.19	3.59				
	71.062	0.58	0.40	5.90	0.48	5.31	0.37	4.35	0.06	2.59				
	70.924	0.44	0.30	5.36	0.34	5.05	0.23	4.03						
	70.787	0.31	0.20	5.10	0.20	3.59	0.10	2.79						
	70.718	0.24	0.15	4.62	0.13	3.54	0.03	1.47						
	70.649	0.17	0.10	3.84	0.07	3.02								
	70.581	0.10	0.05	3.18										
	70.496	0.02	0.01	1.47										
	70.480	0.00	0.00											
	Bottom				0.02	2.64	0.02	1.64	0.02	2.48	0.02	2.15	0.02	1.64
		Average Velocity		5.70		5.31		4.56		4.04		3.52		3.12

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 23 Bed Slope= 0.00000 Temp= 70 F Rock size= 1 in. Side slope 2:1
Q=40 cfs Water Surface Slope= 0.00068 Thickness= 2 in.

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Fraction of Depth	Velocity ft/sec	Location Y=4.0' Depth Z, ft	Velocity ft/sec	Location Y=3.5' Depth Z, ft	Velocity ft/sec	Location Y=3.0' Depth Z, ft	Velocity ft/sec	Location Y=2.5' Depth Z, ft	Velocity ft/sec	Location Y=2.0' Depth Z, ft	Velocity ft/sec
	71.867	1.42	1.00		1.34		1.18		0.92		0.65		0.42	
X=120'	71.727	1.28	0.90	7.22	1.20	6.65	1.04	5.25	0.78	4.57	0.51	4.08	0.28	3.15
	71.585	1.14	0.80	7.12	1.06	6.39	0.90	5.23	0.64	4.32	0.37	3.91	0.14	2.57
	71.442	1.00	0.70	6.89	0.92	6.39	0.76	5.05	0.50	4.01	0.23	3.11		
	71.300	0.86	0.60	6.75	0.77	6.32	0.62	4.78	0.36	3.63	0.09	2.14		
	71.157	0.71	0.50	6.34	0.63	6.13	0.47	4.56	0.21	3.11				
	71.014	0.57	0.40	6.04	0.49	5.74	0.33	4.11	0.07	2.69				
	70.872	0.43	0.30	5.58	0.35	5.12	0.19	3.88						
	70.729	0.28	0.20	4.88	0.20	4.23	0.04	2.59						
	70.658	0.21	0.15	4.60	0.13	3.55								
	70.587	0.14	0.10	3.93	0.06	3.23								
	70.515	0.07	0.05	3.47										
	70.480	0.02	0.01	2.37										
	70.444	0.00	0.00											
	Bottom				0.02	1.79	0.02	2.14	0.02	2.01	0.02	1.64	0.02	1.72
		Average Velocity		5.95		5.59		4.44		3.74		3.33		2.66
	71.834	1.42	1.00		1.30		1.12		0.93		0.66		0.29	
X=130'	71.692	1.28	0.90	7.23	1.16	6.49	0.98	5.84	0.79	4.97	0.51	4.33	0.15	3.11
	71.550	1.13	0.80	7.20	1.01	6.41	0.84	5.63	0.65	4.50	0.37	3.59	0.02	0.00
	71.408	0.99	0.70	6.81	0.87	6.34	0.69	5.56	0.51	4.08	0.23	3.19		
	71.266	0.85	0.60	6.45	0.73	6.19	0.55	5.10	0.37	3.95	0.09	1.64		
	71.125	0.71	0.50	6.25	0.59	5.91	0.41	4.90	0.22	2.98				
	70.983	0.57	0.40	5.86	0.45	5.56	0.27	4.27	0.08	2.32				
	70.841	0.43	0.30	5.36	0.30	4.90	0.13	3.57						
	70.699	0.28	0.20	4.66	0.16	4.43								
	70.628	0.21	0.15	4.24	0.08	3.66								
	70.557	0.14	0.10	3.47										
	70.486	0.07	0.05	2.93										
	70.431	0.02	0.01	2.79										
	70.415	0.00	0.00											
	Bottom				0.02	1.79	0.02	0.00	0.02	2.14	0.02	1.04		
		Average Velocity		5.80		5.57		4.74		3.84		3.21		2.20
	71.800	1.32	1.00		1.19		1.11		0.89		0.56		0.39	
X=140'	71.668	1.19	0.90	7.51	1.06	6.65	0.98	5.74	0.76	5.10	0.43	3.74	0.26	3.44
	71.536	1.06	0.80	7.36	0.93	6.63	0.85	5.62	0.63	4.97	0.30	2.82	0.13	2.54
	71.404	0.92	0.70	7.33	0.79	6.34	0.72	5.59	0.49	4.69	0.16	2.01		
	71.272	0.79	0.60	6.91	0.66	6.30	0.59	5.43	0.36	4.24	0.03	1.04		
	71.140	0.66	0.50	6.65	0.53	6.08	0.45	5.13	0.23	3.47				
	71.008	0.53	0.40	6.19	0.40	5.62	0.32	4.71	0.10	2.84				
	70.876	0.40	0.30	5.96	0.27	5.28	0.19	3.77						
	70.744	0.26	0.20	5.22	0.13	4.25	0.06	2.98						
	70.678	0.20	0.15	4.75	0.07	3.84								
	70.612	0.13	0.10	4.50										
	70.546	0.07	0.05	3.66										
	70.496	0.02	0.01	0.73										
	70.480	0.00	0.00											
	Bottom				0.02	0.00	0.02	1.16	0.02	1.64	0.02	0.00	0.02	0.00
		Average Velocity		6.20		5.88		4.87		4.14		2.59		2.53

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 25 | Bed Slope= 0.00895 | Temp= 71 F | Rock size= 1 in. | Side slope 2:1
Q=40 cfs | Water Surface Slope= 0.00729 | Thickness= 2 in.

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Fraction of Depth	Velocity ft/sec	Location Y=4.0' Depth Z, ft	Velocity ft/sec	Location Y=3.5' Depth Z, ft	Velocity ft/sec	Location Y=3.0' Depth Z, ft	Velocity ft/sec	Location Y=2.5' Depth Z, ft	Velocity ft/sec	Location Y=2.0' Depth Z, ft	Velocity ft/sec
	71.793	1.36	1.00		1.28		1.05		0.87		0.62		0.37	
X=120'	71.657	1.22	0.90	7.56	1.14	7.23	0.91	6.13	0.73	5.31	0.48	4.57	0.23	3.59
	71.521	1.09	0.80	7.36	1.01	7.05	0.78	6.08	0.60	4.91	0.35	4.18	0.10	2.98
	71.385	0.95	0.70	7.26	0.87	6.93	0.64	5.79	0.46	4.63	0.21	3.84		
	71.249	0.81	0.60	6.61	0.73	6.71	0.50	5.56	0.32	4.01	0.08	3.18		
	71.114	0.68	0.50	6.40	0.60	6.19	0.37	5.27	0.19	3.66				
	70.978	0.54	0.40	6.02	0.46	5.74	0.23	4.72	0.05	2.32				
	70.842	0.41	0.30	5.25	0.33	4.85	0.10	3.40						
	70.706	0.27	0.20	4.91	0.19	4.26								
	70.638	0.20	0.15	4.10	0.12	3.06								
	70.570	0.14	0.10	3.47										
	70.502	0.07	0.05	2.84										
	70.440	0.02	0.01	1.16										
	70.434	0.00	0.00											
	Bottom				0.02	2.32	0.02	0.00	0.02	0.00	0.02	2.59	0.02	2.20
		Average Velocity		5.92		5.80		5.10		4.17		3.92		3.15
	71.782	1.33	1.00		1.23		1.08		0.97		0.61		0.36	
X=130'	71.649	1.19	0.90	7.56	1.10	6.95	0.95	5.84	0.84	5.46	0.48	4.57	0.23	3.59
	71.517	1.06	0.80	7.41	0.96	6.65	0.82	5.79	0.70	5.00	0.34	4.11	0.10	2.46
	71.384	0.93	0.70	6.81	0.83	6.55	0.69	5.43	0.57	4.33	0.21	3.44		
	71.251	0.80	0.60	6.53	0.70	6.45	0.55	5.31	0.44	4.01	0.08	2.32		
	71.119	0.66	0.50	6.04	0.57	5.97	0.42	5.28	0.31	3.40				
	70.986	0.53	0.40	5.91	0.43	5.56	0.29	4.63	0.17	2.93				
	70.854	0.40	0.30	5.25	0.30	5.43	0.16	4.56	0.04	2.69				
	70.721	0.27	0.20	4.91	0.17	4.49	0.02	4.33						
	70.655	0.20	0.15	4.26	0.10	3.44								
	70.589	0.13	0.10	4.10	0.04	2.64								
	70.522	0.07	0.05	4.08										
	70.472	0.02	0.01	3.28										
	70.456	0.00	0.00											
	Bottom				0.02	2.14	0.02	0.00	0.02	2.74	0.02	2.01	0.02	0.90
		Average Velocity		5.96		5.74		5.14		4.09		3.64		2.81

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Run 8 29 — Bed Slope= 0.00586 — Temp= 71 F — Rock size= 1 in. — Side slope 2:1
Q=50 cfs — Water Surface Slope= 0.00451 — Thickness= 2 in.

	Elevation (ft)	Location Y=6.0' Depth Z, ft	Location Y=6.0' Fraction of Depth	Location Y=6.0' Velocity ft/sec	Location Y=4.0' Depth Z, ft	Location Y=4.0' Velocity ft/sec	Location Y=3.5' Depth Z, ft	Location Y=3.5' Velocity ft/sec	Location Y=3.0' Depth Z, ft	Location Y=3.0' Velocity ft/sec	Location Y=2.5' Depth Z, ft	Location Y=2.5' Velocity ft/sec	Location Y=2.0' Depth Z, ft	Location Y=2.0' Velocity ft/sec
	72.194	1.73	1.00		1.63		1.44		1.14		0.92		0.76	
X=120'	72.020	1.56	0.90	6.83	1.46	6.65	1.26	5.79	0.97	5.13	0.74	4.63	0.59	3.84
	71.847	1.39	0.80	6.79	1.28	6.55	1.09	5.77	0.79	5.11	0.57	4.33	0.41	3.66
	71.674	1.21	0.70	6.56	1.11	6.55	0.92	5.67	0.62	4.78	0.40	4.01	0.24	3.28
	71.500	1.04	0.60	6.30	0.94	6.52	0.74	5.58	0.45	4.33	0.23	3.47	0.07	1.72
	71.327	0.87	0.50	5.86	0.76	6.17	0.57	5.36	0.27	4.05	0.05	2.32		
	71.153	0.69	0.40	5.70	0.59	5.80	0.40	5.23	0.10	3.06				
	70.980	0.52	0.30	5.18	0.42	5.36	0.22	4.83						
	70.807	0.35	0.20	4.78	0.24	4.46	0.05	4.11						
	70.720	0.26	0.15	4.10	0.16	3.47								
	70.633	0.17	0.10	3.47										
	70.547	0.09	0.05	3.28										
	70.470	0.01	0.01	1.37										
	70.460	0.00	0.00											
	Bottom				0.01	1.37	0.01	2.20	0.01	2.43	0.01	1.87	0.01	1.16
		Average Velocity		5.58		5.66		5.30		4.41		3.87		3.21
	72.150	1.70	1.00		1.59		1.49		1.23		0.92		0.72	
X=130'	71.980	1.53	0.90	6.97	1.42	6.51	1.32	5.79	1.06	5.18	0.74	4.49	0.55	4.18
	71.810	1.36	0.80	6.85	1.25	6.47	1.15	5.67	0.89	4.94	0.57	4.43	0.38	3.74
	71.640	1.19	0.70	6.61	1.08	6.43	0.98	5.67	0.72	4.63	0.40	3.84	0.21	3.28
	71.470	1.02	0.60	6.37	0.91	6.41	0.81	5.56	0.55	4.60	0.23	3.47	0.04	2.32
	71.300	0.85	0.50	6.15	0.74	6.13	0.64	4.86	0.38	4.18	0.06	2.80		
	71.130	0.68	0.40	5.95	0.57	5.91	0.47	4.18	0.21	3.66				
	70.960	0.51	0.30	5.33	0.40	5.43	0.30	3.02	0.04	0.90				
	70.790	0.34	0.20	4.49	0.23	4.72	0.13	1.94						
	70.713	0.25	0.15	4.11	0.14	3.77								
	70.628	0.17	0.10	3.77	0.06	2.84								
	70.543	0.08	0.05	3.15										
	70.460	0.01	0.01	2.01										
	70.450	0.00	0.00											
	Bottom				0.01	2.37	0.01	0.00	0.01	0.00	0.01	2.01	0.01	1.64
		Average Velocity		5.70		5.73		4.49		4.19		3.86		3.51
	72.182	1.66	1.00		1.62		1.40		1.10		0.93		0.93	
X=140'	71.998	1.49	0.90	7.12	1.45	6.75	1.24	5.91	0.94	5.23	0.77	4.57	0.77	4.33
	71.834	1.33	0.80	7.03	1.29	6.73	1.07	5.88	0.78	5.05	0.60	4.43	0.60	4.14
	71.669	1.17	0.70	6.88	1.12	6.60	0.91	5.81	0.61	4.97	0.44	4.08	0.44	3.44
	71.505	1.00	0.60	6.66	0.96	6.65	0.74	5.67	0.45	4.71	0.28	3.63	0.28	2.43
	71.341	0.84	0.50	6.15	0.80	6.34	0.58	5.43	0.28	4.41	0.11	3.28		
	71.176	0.67	0.40	5.95	0.63	5.91	0.41	5.21	0.12	3.59				
	71.012	0.51	0.30	5.79	0.47	5.60	0.25	4.71						
	70.848	0.34	0.20	4.91	0.30	5.05	0.08	3.66						
	70.765	0.26	0.15	4.49	0.22	4.49								
	70.683	0.16	0.10	4.01	0.14	3.81								
	70.601	0.08	0.05	3.28	0.06	3.36								
	70.529	0.01	0.01	2.32										
	70.519	0.00	0.00											
	Bottom				0.01	2.32	0.01	2.74	0.01	1.84	0.01	2.01	0.01	1.87
		Average Velocity		5.88		5.86		5.28		4.56		3.93		3.32

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Run # 30 Bed Slope= 0.00701 Temp= 72 F Rock Size= 1 in. Side slope 2:1
Q=50 cfs Water Surface Slope= 0.00449 Thickness= 2 in.

	Location Y=6.0'				Location Y=4.0'			Location Y=3.50'			Location Y=3.0'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.064	1.564	1.00		72.055	1.507		72.072	1.301		72.066	1.096	
X=140'	71.908	1.408	0.90	7.67	71.850	1.302	7.01	71.970	1.199	6.39	71.980	1.010	5.74
	71.751	1.251	0.80	7.60	71.750	1.202	6.99	71.870	1.099	6.39	71.880	0.910	5.56
	71.595	1.095	0.70	7.42	71.650	1.102	6.97	71.770	0.999	6.28	71.780	0.810	5.48
	71.438	0.938	0.60	7.16	71.550	1.002	6.85	71.670	0.899	6.28	71.680	0.710	5.42
	71.282	0.782	0.50	6.87	71.450	0.902	6.75	71.570	0.799	6.13	71.580	0.610	4.94
	71.126	0.626	0.40	6.63	71.350	0.802	6.46	71.470	0.699	5.84	71.480	0.510	4.89
	70.969	0.469	0.40	6.17	71.250	0.702	6.26	71.370	0.599	5.74	71.380	0.410	4.75
	70.813	0.313	0.20	5.60	71.150	0.602	6.02	71.270	0.499	5.43	71.330	0.360	4.60
	70.735	0.235	0.15	5.13	71.050	0.502	5.79	71.170	0.399	5.15	71.280	0.310	4.57
	70.656	0.156	0.10	4.11	70.950	0.402	5.41	71.120	0.349	4.91	71.240	0.270	4.55
	70.578	0.078	0.05	3.15	70.900	0.352	5.31	71.070	0.299	4.78	71.200	0.230	4.30
	70.510	0.010	0.01	2.64	70.850	0.302	5.10	71.030	0.259	4.49	71.160	0.190	3.77
	70.500	0.000	0.00		70.810	0.262	4.83	70.990	0.219	4.43	71.120	0.150	3.70
					70.770	0.222	4.49	70.950	0.179	4.27	71.080	0.110	3.47
					70.730	0.182	4.24	70.910	0.139	4.01	71.060	0.090	3.44
					70.690	0.142	3.88	70.870	0.099	3.81	71.040	0.070	3.40
					70.650	0.102	3.51	70.850	0.079	3.63	71.020	0.050	3.36
					70.630	0.082	3.28	70.830	0.059	1.79	71.000	0.030	3.36
					70.610	0.062	2.84	70.810	0.039	0.73	70.980	0.010	3.11
					70.590	0.042	2.59	70.790	0.019	0.73			
					70.570	0.022	1.16	70.781	0.010	0.00			
					70.558	0.010	0.73						
	Average Velocity			6.64			5.90			5.35			4.80

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 31 Bed Slope= 0.00085 Temp= 72 F Rock size= 1 in. Side slope 2:1
Q=40 cfs Water Surface Slope= 0.00560 Thickness= 2 in.

	Location Y=6.0'				Location Y=4.0'			Location Y=3.5'			Location Y=3.0'			Location Y=2.5'			Location Y=2.0'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.885	1.350	1.00		71.885	1.277		71.885	1.134		71.885	0.927		71.885	0.722		71.885	0.389	
X=120'	71.750	1.215	0.90	7.47	71.810	1.202	6.85	71.750	0.999	5.81	71.760	0.802	5.18	71.760	0.597	4.60	71.810	0.314	3.79
	71.615	1.080	0.80	7.36	71.710	1.102	6.81	71.650	0.899	5.79	71.660	0.702	5.05	71.660	0.497	4.38	71.760	0.264	3.63
	71.480	0.945	0.70	7.18	71.610	1.002	6.79	71.550	0.799	5.67	71.560	0.602	4.63	71.560	0.397	4.01	71.720	0.224	3.53
	71.345	0.810	0.60	6.95	71.510	0.902	6.79	71.450	0.699	5.52	71.460	0.502	4.40	71.510	0.347	3.84	71.680	0.184	3.36
	71.210	0.675	0.50	6.63	71.410	0.802	6.71	71.350	0.599	5.46	71.360	0.402	4.18	71.460	0.297	3.59	71.640	0.144	3.11
	71.075	0.540	0.40	6.13	71.310	0.702	6.55	71.250	0.499	5.38	71.310	0.352	4.01	71.420	0.257	3.51	71.600	0.104	2.98
	70.940	0.405	0.30	5.67	71.210	0.602	6.41	71.150	0.399	5.18	71.260	0.302	3.89	71.380	0.217	3.26	71.580	0.084	2.84
	70.805	0.270	0.20	4.91	71.110	0.502	6.09	71.100	0.349	4.80	71.220	0.262	3.77	71.340	0.177	2.84	71.560	0.064	2.78
	70.738	0.203	0.15	4.43	71.010	0.402	5.67	71.050	0.299	4.69	71.180	0.222	3.59	71.300	0.137	2.77	71.540	0.044	2.58
	70.670	0.135	0.10	4.05	70.960	0.352	5.37	71.010	0.259	4.49	71.140	0.182	3.42	71.260	0.097	2.43	71.520	0.024	2.33
	70.603	0.068	0.05	3.28	70.910	0.302	5.25	70.970	0.219	4.36	71.100	0.142	3.28	71.240	0.077	2.01	71.506	0.010	2.32
	70.545	0.010	0.00	2.69	70.870	0.262	4.86	70.930	0.179	4.01	71.060	0.102	3.06	71.220	0.057	1.20			
	70.535	0.000	0.00		70.830	0.222	4.43	70.890	0.139	3.77	71.040	0.082	2.98	71.200	0.037	1.01			
					70.790	0.182	4.05	70.850	0.099	3.47	71.020	0.062	2.82	71.180	0.017	0.90			
					70.750	0.142	3.63	70.830	0.079	3.28	71.000	0.042	2.69	71.173	0.010	0.90			
					70.710	0.102	2.71	70.810	0.059	3.19	70.980	0.022	2.32						
					70.690	0.082	2.48	70.790	0.039	2.64	70.968	0.010	1.87						
					70.670	0.062	1.94	70.770	0.019	2.12									
					70.650	0.042	1.60	70.761	0.010	1.55									
					70.630	0.022	1.37												
					70.610	0.010	1.04												
	Average Velocity			6.12			5.72			5.02			4.18			3.55			3.22

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 33	Bed Slope= 0.01103	Temp= 72 F	Rock size= 1 in.	Side slope 2:1
Q=20 cfs	Water Surface Slope= 0.00021		Thickness= 2 in.	

	Location Y=6.0'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'			Location Y=2.8'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
					71.375	0.019													
X=120'					71.200	0.704	5.23												
					71.100	0.604	5.00												
					71.000	0.504	4.75												
					70.900	0.404	4.40												
					70.910	0.354	4.18												
					70.800	0.304	3.90												
					70.820	0.264	3.65												
					70.700	0.224	3.67												
					70.740	0.184	3.52												
					70.700	0.144	2.80												
					70.600	0.104	2.54												
					70.640	0.084	2.10												
					70.620	0.064	1.52												
					70.600	0.044	0.98												
					70.580	0.024	1.19												
					70.566	0.010	1.34												
	Average Velocity						4.04												
	71.380	0.80	1.00		71.380	0.83		71.350	0.71		71.350	0.63		71.350	0.43		71.380	0.31	
X=130'	71.271	0.79	0.90	6.30	71.230	0.70	5.20	71.250	0.61	4.65	71.230	0.50	4.31	71.230	0.30	3.85	71.230	0.18	2.88
	71.183	0.70	0.80	6.22	71.130	0.60	4.90	71.150	0.51	4.40	71.130	0.40	3.81	71.190	0.26	3.70	71.190	0.14	2.65
	71.085	0.61	0.70	5.90	71.030	0.50	4.40	71.080	0.41	4.21	71.080	0.35	3.55	71.150	0.22	3.50	71.190	0.10	2.31
	71.007	0.53	0.60	5.67	70.930	0.40	4.23	71.000	0.36	3.74	71.030	0.30	3.47	71.110	0.18	3.28	71.130	0.08	2.08
	70.920	0.44	0.50	5.51	70.880	0.35	4.04	70.980	0.31	3.85	70.980	0.26	3.30	71.070	0.14	3.11	71.110	0.06	2.01
	70.832	0.35	0.40	5.23	70.830	0.30	3.97	70.910	0.27	3.50	70.980	0.22	2.86	71.030	0.10	2.92	71.080	0.04	1.92
	70.744	0.26	0.30	4.92	70.780	0.26	3.50	70.870	0.23	3.21	70.910	0.18	2.83	71.010	0.08	2.84	71.070	0.02	1.78
	70.656	0.18	0.20	4.21	70.750	0.22	3.45	70.830	0.19	3.02	70.870	0.14	2.37	70.990	0.06	2.54	71.056	0.01	1.74
	70.613	0.13	0.15	3.80	70.710	0.18	3.26	70.790	0.15	2.87	70.830	0.10	2.03	70.970	0.04	2.46			
	70.580	0.08	0.10	3.50	70.670	0.14	3.11	70.750	0.11	2.80	70.810	0.08	2.01	70.950	0.02	2.24			
	70.525	0.04	0.05	3.15	70.630	0.10	2.72	70.730	0.08	2.54	70.790	0.06	1.90	70.937	0.01	2.09			
	70.491	0.01	0.00	2.80	70.610	0.08	2.54	70.710	0.07	2.35	70.770	0.04	1.80						
	70.481	0.00	0.00		70.590	0.06	2.06	70.680	0.05	2.34	70.750	0.02	1.56						
					70.570	0.04	1.79	70.670	0.03	1.97	70.736	0.01	1.44						
					70.550	0.02	1.13	70.664	0.01	1.13									
					70.543	0.01	0.84												
	Average Velocity			5.20			4.04			3.00			3.24			3.32			2.12
	71.385	0.85	1.00		71.385	0.78		71.385	0.66		71.385	0.60		71.385	0.47		71.355	0.27	
X=140'	71.271	0.76	0.90		71.280	0.71	5.41	71.310	0.61	5.00	71.250	0.40	4.84	71.300	0.41	4.54	71.310	0.23	3.44
	71.186	0.68	0.80	6.42	71.180	0.61	5.34	71.210	0.51	4.75	71.150	0.38	4.47	71.250	0.36	4.43	71.270	0.19	3.26
	71.102	0.59	0.70	6.22	71.080	0.51	5.02	71.110	0.41	4.65	71.100	0.34	4.21	71.200	0.31	4.32	71.230	0.15	3.13
	71.017	0.51	0.60	5.92	70.980	0.41	4.79	71.080	0.36	4.80	71.080	0.29	4.12	71.160	0.27	4.21	71.190	0.11	2.98
	70.838	0.42	0.50	5.70	70.930	0.36	4.80	71.010	0.31	4.40	71.010	0.25	3.97	71.120	0.23	3.91	71.170	0.09	3.00
	70.848	0.34	0.40	5.37	70.880	0.31	4.67	70.970	0.27	4.15	70.970	0.21	3.60	71.080	0.19	3.66	71.150	0.07	2.86
	70.764	0.25	0.30	5.00	70.840	0.27	4.25	70.930	0.23	3.96	70.930	0.17	3.50	71.040	0.15	3.40	71.130	0.05	2.63
	70.679	0.17	0.20	4.30	70.800	0.23	4.00	70.890	0.19	3.97	70.890	0.13	3.26	71.000	0.11	3.12	71.110	0.03	2.49
	70.595	0.08	0.10	3.52	70.760	0.19	4.00	70.850	0.15	3.50	70.850	0.09	2.76	70.999	0.01	2.03	71.092	0.01	2.20
	70.552	0.04	0.05	2.80	70.720	0.15	3.72	70.810	0.11	3.33	70.830	0.07	2.63						
	70.520	0.01	0.00	2.20	70.680	0.11	3.16	70.790	0.09	3.03	70.810	0.05	2.20						
	70.510	0.00	0.00		70.660	0.09	2.80	70.770	0.07	2.90	70.790	0.03	2.06						
					70.640	0.07	2.50	70.750	0.05	2.70	70.770	0.01	1.40						
					70.620	0.05	2.20	70.730	0.03	2.30									
					70.600	0.03	1.30	70.700	0.01	2.12									
					70.582	0.01	1.02												
	Average Velocity			4.84			4.30			4.13			3.07			3.69			2.98

CORPS OF ENGINEERS RIPRAP PROJECT

Run 3 34 — Q=20 cfs — Bed Slope= 0.01300 — Water Surface Slope= 0.01112 — Temp= 72 F — Rock size= 1 in. — Thickness= 2 in. — Side slope 2:1

	Location Y=6.00'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'			Location Y=2.8'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.334	0.82	1.00		71.334	0.78		71.334	0.60		71.334	0.494		71.334	0.464		71.334	0.274	
X=120'	71.252	0.73	0.90	6.90	71.200	0.71	5.84	71.280	0.55	5.30	71.280	0.440	4.81	71.280	0.410	4.54	71.290	0.230	3.59
	71.171	0.65	0.80	6.71	71.100	0.61	5.62	71.240	0.51	5.08	71.250	0.410	4.75	71.180	0.310	4.40	71.250	0.190	3.59
	71.080	0.57	0.70	6.42	71.000	0.51	5.44	71.140	0.41	4.95	71.150	0.310	4.40	71.140	0.270	4.17	71.210	0.150	3.21
	71.007	0.49	0.60	6.11	70.900	0.41	5.00	71.040	0.31	4.68	71.110	0.270	4.25	71.100	0.230	3.68	71.170	0.110	3.11
	70.926	0.41	0.50	5.79	70.800	0.31	4.61	71.000	0.27	4.61	71.070	0.230	4.25	71.060	0.190	3.50	71.150	0.080	3.00
	70.844	0.33	0.40	5.44	70.820	0.27	4.32	70.980	0.23	4.40	71.030	0.190	3.85	71.020	0.150	3.11	71.130	0.070	2.78
	70.762	0.24	0.30	4.95	70.780	0.23	4.01	70.920	0.19	4.32	70.990	0.150	3.59	70.980	0.110	2.78	71.110	0.050	2.66
	70.680	0.16	0.20	4.40	70.740	0.19	3.59	70.880	0.15	3.93	70.950	0.110	3.11	70.960	0.080	2.41	71.090	0.030	2.66
	70.640	0.12	0.15	4.17	70.700	0.15	3.21	70.840	0.11	3.88	70.930	0.080	2.78	70.940	0.070	2.27	71.070	0.010	2.66
	70.599	0.08	0.10	3.31	70.660	0.11	3.00	70.820	0.09	3.59	70.910	0.070	2.41	70.920	0.050	1.79			
	70.558	0.04	0.05	3.00	70.640	0.09	2.78	70.800	0.07	3.31	70.890	0.050	2.12	70.900	0.030	1.39			
	70.527	0.01	0.00	2.86	70.620	0.07	2.54	70.780	0.05	3.31	70.870	0.030	1.97	70.880	0.010	1.13			
	70.517	0.00	0.00		70.600	0.05	2.27	70.760	0.03	3.00	70.850	0.010	1.79						
					70.580	0.03	1.79	70.741	0.01	2.80									
					70.560	0.01	1.39												
	Average Velocity			5.40			4.54			4.45			3.83			3.40			3.13
	71.321	0.86	1.00		71.321	0.75		71.321	0.65		71.321	0.57		71.321	0.40		71.321	0.28	
X=130'	71.235	0.78	0.90	7.00	71.200	0.71	5.87	71.280	0.60	5.20	71.250	0.50	4.95	71.280	0.36	4.40	71.270	0.23	3.11
	71.149	0.69	0.80	6.71	71.000	0.51	5.44	71.180	0.51	4.95	71.190	0.46	4.61	71.220	0.30	4.40	71.230	0.19	2.88
	71.063	0.60	0.70	6.57	70.900	0.41	5.14	71.080	0.46	4.81	71.050	0.38	4.01	71.180	0.26	4.32	71.190	0.15	2.86
	70.977	0.52	0.60	6.16	70.800	0.31	4.54	70.980	0.31	4.32	71.010	0.26	3.78	71.140	0.22	4.00	71.150	0.11	2.54
	70.891	0.43	0.50	5.87	70.860	0.27	4.40	70.940	0.26	4.25	70.970	0.22	3.50	71.100	0.18	3.85	71.130	0.09	2.41
	70.806	0.34	0.40	5.44	70.800	0.23	4.17	70.900	0.23	4.00	70.930	0.18	3.21	71.060	0.14	3.60	71.110	0.07	2.27
	70.718	0.26	0.30	5.20	70.760	0.19	3.78	70.860	0.18	3.78	70.890	0.14	3.00	71.020	0.10	3.31	71.090	0.05	2.12
	70.632	0.17	0.20	4.17	70.720	0.15	3.68	70.820	0.14	3.68	70.850	0.10	2.86	71.000	0.08	3.00	71.070	0.03	1.97
	70.590	0.13	0.15	4.01	70.680	0.11	3.31	70.780	0.10	3.40	70.830	0.08	2.54	70.980	0.06	2.78	71.053	0.01	1.97
	70.546	0.09	0.10	3.50	70.660	0.09	3.00	70.760	0.08	3.11	70.810	0.06	2.27	70.960	0.04	2.66			
	70.503	0.04	0.05	3.00	70.640	0.07	2.54	70.740	0.06	3.00	70.790	0.04	2.12	70.940	0.02	2.54			
	70.470	0.01	0.00	2.86	70.620	0.06	2.54	70.720	0.04	2.54	70.770	0.02	1.97	70.920	0.01	2.27			
	70.460	0.00	0.00		70.600	0.03	2.27	70.700	0.03	2.27	70.750	0.01	1.80						
					70.583	0.01	1.97	70.686	0.01	2.12									
	Average Velocity			5.51			4.56			4.20			3.75			3.73			2.58
	71.317	0.80	1.00		71.317	0.76		71.317	0.85		71.317	0.53		71.317	0.42		71.317	0.38	
X=140'	71.237	0.72	0.90		71.270	0.71	6.06	71.270	0.80	5.26	71.270	0.49	4.81	71.270	0.37	5.01	71.280	0.34	4.25
	71.157	0.64	0.80	7.06	71.070	0.51	5.73	71.170	0.51	5.14	71.190	0.41	4.61	71.190	0.29	4.88	71.240	0.30	4.25
	71.077	0.56	0.70	6.76	70.970	0.41	5.32	71.070	0.46	4.88	71.080	0.31	4.32	71.150	0.25	4.60	71.200	0.26	4.25
	70.997	0.48	0.60	6.52	70.870	0.31	4.80	70.970	0.31	4.40	71.050	0.27	4.25	71.110	0.21	4.40	71.160	0.22	4.01
	70.917	0.40	0.50	6.11	70.830	0.27	4.88	70.930	0.27	4.25	71.010	0.23	3.93	71.070	0.17	4.01	71.120	0.18	3.76
	70.836	0.32	0.40	5.86	70.790	0.23	4.25	70.890	0.23	4.17	70.970	0.19	3.50	71.030	0.13	3.68	71.080	0.14	3.40
	70.756	0.24	0.30	5.07	70.750	0.19	4.17	70.850	0.18	3.78	70.930	0.15	3.31	70.990	0.09	3.11	71.040	0.10	2.89
	70.676	0.16	0.20	4.55	70.710	0.15	3.78	70.810	0.15	3.50	70.890	0.11	2.78	70.970	0.07	2.86	71.020	0.08	2.54
	70.636	0.12	0.15	4.32	70.670	0.11	3.50	70.770	0.10	3.00	70.870	0.09	2.54	70.950	0.05	2.27	71.000	0.06	2.54
	70.596	0.08	0.10	3.93	70.650	0.09	3.11	70.750	0.08	2.86	70.850	0.07	2.12	70.930	0.03	1.60	70.980	0.04	2.27
	70.556	0.04	0.05	3.11	70.630	0.07	2.78	70.730	0.07	2.41	70.830	0.05	1.80	70.910	0.01	1.16	70.960	0.02	2.27
	70.526	0.01	0.00	2.12	70.610	0.05	2.27	70.710	0.06	1.79	70.810	0.03	1.13				70.946	0.01	2.00
	70.516	0.00	0.00		70.590	0.03	1.79	70.690	0.03	1.00	70.794	0.01	0.76						
					70.570	0.01	1.39	70.675	0.01	1.13									
	Average Velocity			5.66			4.78			4.16			3.71			3.93			3.40

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 35   Bed Slope= 0.01400   Temp= 71 F   Rock size= 1 in.   Side slope 2:1
Q=[illegible] cfs   Water Surface Slope= 0.01310   Thickness= 2 in.

	Location Y=6.0'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'			Location Y=2.8'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.310	0.80	1.00		71.310	0.74		71.310	0.70		71.310	0.57		71.310	0.38		71.310	0.23	
X=120'	71.230	0.72	0.90	7.13	71.280	0.71	6.08	71.280	0.65	5.44	71.250	0.51	4.95	71.280	0.35	4.61	71.270	0.19	3.31
	71.150	0.64	0.80	6.90	71.080	0.51	5.67	71.120	0.51	5.08	71.150	0.41	4.40	71.240	0.31	4.61	71.230	0.15	3.00
	71.071	0.56	0.70	6.52	70.980	0.41	5.26	71.020	0.40	4.75	71.050	0.31	4.17	71.200	0.27	4.40	71.190	0.11	2.54
	70.991	0.48	0.60	6.42	70.880	0.31	4.81	70.920	0.31	4.32	71.010	0.27	3.50	71.160	0.23	4.25	71.170	0.09	2.54
	70.911	0.40	0.50	5.95	70.840	0.27	4.61	70.880	0.26	4.01	70.970	0.23	3.31	71.120	0.19	3.93	71.150	0.07	2.54
	70.831	0.32	0.40	5.30	70.800	0.23	4.25	70.840	0.23	3.76	70.930	0.19	3.00	71.080	0.15	3.85	71.130	0.05	2.41
	70.751	0.24	0.30	5.20	70.760	0.19	4.01	70.800	0.18	3.50	70.890	0.15	2.80	71.040	0.11	3.50	71.110	0.03	1.97
	70.672	0.16	0.20	4.81	70.720	0.15	3.50	70.780	0.15	3.00	70.850	0.11	1.97	71.020	0.09	3.21	71.090	0.01	1.97
	70.632	0.12	0.15	4.32	70.680	0.11	3.31	70.720	0.10	2.66	70.830	0.09	1.30	71.000	0.07	3.00			
	70.592	0.08	0.10	3.40	70.660	0.09	3.00	70.700	0.08	2.41	70.810	0.07	0.00	70.980	0.05	2.54			
	70.552	0.04	0.05	2.80	70.640	0.07	2.70	70.680	0.07	2.27	70.790	0.05	0.00	70.960	0.03	2.12			
	70.522	0.01	0.01	2.41	70.620	0.05	2.54	70.660	0.04	2.12	70.770	0.03	0.00	70.940	0.01	1.78			
	70.512	0.00	0.00		70.600	0.03	1.97	70.640	0.03	1.97	70.750	0.01	0.00						
					70.581	0.01	1.08	70.625	0.01	1.78									
	Average Velocity			5.03			4.70			4.14			3.33			3.76			2.87
	71.301	0.76	1.00		71.301	0.74		71.301	0.58		71.301	0.48		71.301	0.38		71.301	0.21	
X=130'	71.225	0.68	0.90	7.10	71.270	0.70	6.16	71.280	0.56	5.30	71.290	0.46	5.01	71.280	0.37	4.67	71.280	0.19	3.00
	71.190	0.61	0.80	7.08	71.070	0.50	5.98	71.220	0.50	5.30	71.230	0.41	4.88	71.220	0.31	4.40	71.240	0.15	3.00
	71.074	0.53	0.70	6.71	70.970	0.40	5.26	71.120	0.40	5.00	71.130	0.31	4.54	71.180	0.27	4.00	71.200	0.11	2.80
	70.990	0.45	0.60	6.47	70.870	0.30	4.75	71.020	0.30	4.80	71.090	0.27	4.25	71.140	0.23	3.76	71.180	0.09	2.70
	70.923	0.38	0.50	5.88	70.830	0.26	4.47	70.980	0.26	4.47	71.050	0.23	4.01	71.100	0.19	3.40	71.160	0.07	2.41
	70.847	0.30	0.40	5.73	70.790	0.22	4.25	70.940	0.22	4.32	71.010	0.19	3.76	71.060	0.15	2.80	71.140	0.05	2.12
	70.771	0.23	0.30	5.50	70.750	0.18	3.88	70.900	0.18	4.25	70.970	0.15	3.31	71.020	0.11	2.41	71.120	0.03	2.12
	70.695	0.15	0.20	4.81	70.710	0.14	3.50	70.860	0.14	3.76	70.930	0.11	3.11	71.000	0.09	2.12	71.102	0.01	1.97
	70.658	0.11	0.15	4.17	70.670	0.10	3.11	70.820	0.10	3.80	70.910	0.09	2.89	70.980	0.07	1.97			
	70.620	0.08	0.10	4.01	70.650	0.08	2.80	70.800	0.08	3.50	70.890	0.07	2.80	70.960	0.05	1.78			
	70.582	0.04	0.05	3.88	70.630	0.06	2.66	70.780	0.06	3.31	70.870	0.05	2.54	70.940	0.03	0.00			
	70.564	0.01	0.02	2.41	70.610	0.04	2.12	70.760	0.04	3.00	70.850	0.03	2.41	70.920	0.01	0.00			
	70.544	0.00	0.00		70.590	0.02	1.78	70.740	0.02	2.70	70.835	0.01	2.41						
					70.576	0.01	1.00	70.728	0.01	2.41									
	Average Velocity			5.78			4.08			4.42			3.90			3.12			2.80
	71.297	0.78	1.00		71.297	0.75		71.297	0.66		71.297	0.52		71.297	0.35		71.297	0.29	
X=140'	71.219	0.70	0.90	7.13	71.250	0.71	6.22	71.280	0.61	5.87	71.280	0.48	5.20	71.250	0.31	4.81	71.280	0.27	3.50
	71.141	0.63	0.80	7.08	71.060	0.51	6.01	71.180	0.51	5.50	71.180	0.40	5.01	71.210	0.27	4.81	71.240	0.23	3.50
	71.062	0.55	0.70	6.87	70.960	0.41	5.26	71.080	0.41	5.26	71.080	0.30	4.54	71.170	0.23	4.54	71.200	0.19	3.31
	70.984	0.47	0.60	6.47	70.860	0.31	5.14	70.980	0.31	4.81	71.040	0.26	4.32	71.130	0.19	4.32	71.160	0.15	2.80
	70.906	0.39	0.50	6.11	70.818	0.27	4.95	70.938	0.27	4.67	71.000	0.22	4.01	71.090	0.15	4.01	71.120	0.11	2.54
	70.828	0.31	0.40	5.86	70.778	0.23	4.75	70.900	0.23	4.01	70.980	0.18	3.50	71.050	0.11	3.50	71.100	0.09	2.54
	70.750	0.23	0.30	5.55	70.738	0.19	4.54	70.860	0.19	3.65	70.920	0.14	3.00	71.030	0.09	3.11	71.080	0.07	2.41
	70.671	0.16	0.20	4.81	70.698	0.15	3.88	70.820	0.15	3.50	70.880	0.10	2.41	71.010	0.07	2.54	71.060	0.05	1.97
	70.632	0.12	0.15	4.17	70.660	0.11	3.50	70.780	0.11	3.11	70.860	0.08	2.12	70.990	0.05	1.78	71.040	0.03	0.76
	70.593	0.08	0.10	3.50	70.630	0.09	3.11	70.740	0.08	2.70	70.840	0.06	1.00	70.970	0.03	1.13	71.020	0.01	[illegible]
	70.554	0.04	0.05	2.54	70.610	0.07	2.70	70.720	0.07	1.97	70.820	0.04	1.13	70.962	0.01	1.13			
	70.525	0.01	0.02	1.78	70.590	0.05	1.78	70.700	0.05	1.30	70.800	0.02	0.44						
	70.515	0.00	0.00		70.570	0.03	0.80	70.680	0.03	1.13	70.787	0.01	0.00						
					70.552	0.01	0.72	70.660	0.01	0.67									
	Average Velocity			5.74			4.91			4.20			3.74			3.73			2.63

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 37 — Bed Slope= 0.01003 — Temp= 72 F — Rock size= 1 in. — Side slope 2:1

Q=15 cfs — Water Surface Slope= 0.01002 — Thickness= 1.5 in.

	Location Y=6.0'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.191	0.77	1.00		71.191	0.72		71.191	0.66		71.191	0.40		71.191	0.33	
X=120'	71.115	0.69	0.90	6.33	71.105	0.69	4.83	71.145	0.61	4.29	71.120	0.41	3.92	71.170	0.31	3.42
	71.038	0.61	0.80	6.06	70.985	0.51	4.83	71.045	0.51	3.90	71.020	0.31	3.56	71.130	0.27	3.42
	70.961	0.54	0.70	5.70	70.885	0.41	4.40	70.945	0.41	3.77	70.980	0.27	3.42	71.090	0.23	3.34
	70.885	0.46	0.60	5.03	70.785	0.31	4.00	70.845	0.31	3.50	70.940	0.23	3.00	71.050	0.19	3.19
	70.808	0.38	0.50	5.17	70.745	0.27	3.96	70.805	0.27	3.32	70.900	0.19	2.77	71.010	0.15	2.80
	70.731	0.31	0.40	5.00	70.705	0.23	3.50	70.765	0.23	3.27	70.860	0.15	2.45	70.970	0.11	2.58
	70.655	0.23	0.30	4.06	70.665	0.19	3.16	70.725	0.19	3.00	70.820	0.11	2.16	70.950	0.09	2.27
	70.578	0.15	0.20	3.80	70.625	0.15	2.58	70.685	0.15	2.42	70.800	0.09	1.96	70.930	0.07	2.00
	70.540	0.12	0.15	3.65	70.585	0.11	2.08	70.645	0.11	2.00	70.780	0.07	1.78	70.910	0.05	1.87
	70.502	0.08	0.10	2.58	70.565	0.09	1.87	70.625	0.09	1.53	70.760	0.05	1.23	70.890	0.03	1.63
	70.463	0.04	0.05	0.89	70.545	0.07	1.78	70.605	0.07	1.42	70.740	0.03	0.58	70.870	0.01	1.50
	70.435	0.01	0.01	0.00	70.525	0.05	1.47	70.585	0.05	1.08	70.720	0.01	0.00			
	70.425	0.00	0.00		70.505	0.03	1.36	70.565	0.03	0.41						
					70.485	0.01	1.23	70.545	0.01	0.00						
	Average Velocity			4.78			3.70			3.15			2.84			2.73
	71.185	0.75	1.00		71.185	0.68		71.185	0.61		71.185	0.45		71.185	0.35	
X=130'	71.110	0.68	0.90	5.92	71.103	0.61	5.00	71.150	0.57	4.60	71.150	0.41	4.21	71.150	0.31	3.58
	71.034	0.60	0.80	5.63	71.003	0.51	4.83	71.000	0.51	4.50	71.050	0.31	3.92	71.110	0.27	3.54
	70.958	0.53	0.70	5.63	70.903	0.41	4.66	70.900	0.41	4.30	71.010	0.27	3.88	71.070	0.23	3.34
	70.883	0.45	0.60	5.33	70.803	0.31	4.32	70.880	0.31	3.96	70.970	0.23	3.49	71.030	0.19	3.16
	70.808	0.38	0.50	5.17	70.763	0.27	4.00	70.850	0.27	3.80	70.930	0.19	3.29	70.990	0.15	2.97
	70.732	0.30	0.40	5.00	70.723	0.23	3.65	70.810	0.23	3.42	70.890	0.15	3.00	70.950	0.11	2.55
	70.657	0.23	0.30	4.40	70.683	0.19	3.51	70.770	0.19	3.27	70.850	0.11	2.77	70.930	0.09	1.87
	70.581	0.15	0.20	4.29	70.643	0.15	3.16	70.730	0.15	2.74	70.830	0.09	2.45	70.910	0.07	1.63
	70.543	0.11	0.15	3.88	70.603	0.11	2.83	70.690	0.11	2.31	70.810	0.07	2.35	70.890	0.05	1.53
	70.506	0.08	0.10	3.42	70.583	0.09	2.58	70.670	0.09	2.04	70.790	0.05	1.53	70.870	0.03	1.42
	70.468	0.04	0.05	1.83	70.563	0.07	2.04	70.650	0.07	1.78	70.770	0.03	1.36	70.850	0.01	1.29
	70.440	0.01	0.01	0.50	70.543	0.05	1.03	70.630	0.05	1.42	70.750	0.01	1.23			
	70.430	0.00	0.00		70.523	0.03	1.23	70.610	0.03	1.23						
					70.503	0.01	0.91	70.590	0.01	1.16						
	Average Velocity			4.79			3.96			3.51			3.21			2.71
	71.172	0.74	1.00		71.172	0.64		71.172	0.55		71.172	0.40		71.172	0.28	
X=140'	71.098	0.66	0.90	6.06	71.145	0.61	5.33	71.135	0.51	5.00	71.130	0.36	4.66	71.125	0.23	4.00
	71.025	0.59	0.80	5.70	71.045	0.51	5.17	71.035	0.41	5.00	71.080	0.31	4.66	71.085	0.19	3.86
	70.951	0.52	0.70	5.40	70.945	0.41	4.83	70.935	0.31	4.65	71.040	0.27	4.48	71.045	0.15	3.74
	70.877	0.44	0.60	5.46	70.865	0.31	4.66	70.895	0.27	4.48	71.000	0.23	4.32	71.005	0.11	3.39
	70.804	0.37	0.50	5.00	70.825	0.27	4.55	70.855	0.23	4.40	70.960	0.19	3.96	70.985	0.09	3.14
	70.730	0.30	0.40	4.06	70.785	0.23	4.25	70.815	0.19	4.19	70.920	0.15	3.70	70.965	0.07	2.96
	70.656	0.22	0.30	4.00	70.725	0.19	4.08	70.775	0.15	3.60	70.880	0.11	3.16	70.945	0.05	2.68
	70.582	0.15	0.20	3.65	70.685	0.15	3.83	70.735	0.11	3.19	70.860	0.09	2.80	70.925	0.03	2.31
	70.546	0.11	0.15	3.16	70.645	0.11	3.61	70.715	0.09	2.86	70.840	0.07	2.65	70.905	0.01	2.00
	70.508	0.07	0.10	2.58	70.625	0.09	3.42	70.695	0.07	2.62	70.820	0.05	2.52			
	70.472	0.04	0.05	1.80	70.605	0.07	3.00	70.675	0.05	2.55	70.800	0.03	2.27			
	70.446	0.01	0.01	0.30	70.585	0.05	2.00	70.655	0.03	1.70	70.780	0.01	2.20			
	70.436	0.00	0.00		70.565	0.03	2.20	70.635	0.01	1.53						
					70.545	0.01	2.00									
	Average Velocity			4.81			4.33			4.00			3.74			3.36

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 38 — Bed Slope= 0.01106 — Temp= 71 F — Rock size= 1 in. — Side slope 2:1

Q=15 cfs — Water Surface Slope= 0.01105 — Thickness= 1.5 in.

	Location Y=6.0'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.171	0.72	1.00		71.171	0.67		71.171	0.60		71.171	0.46		71.171	0.34	
X=120'	71.099	0.65	0.90	6.06	71.110	0.61	4.83	71.080	0.51	4.09	71.100	0.39	3.85	71.100	0.27	3.16
	71.028	0.58	0.80	5.92	71.010	0.51	4.83	70.980	0.41	4.00	71.020	0.31	3.56	71.060	0.23	2.97
	70.958	0.50	0.70	5.70	70.910	0.41	4.66	70.880	0.31	3.79	70.980	0.27	3.34	71.020	0.19	2.80
	70.884	0.43	0.60	5.63	70.810	0.31	4.29	70.840	0.27	3.59	70.940	0.23	3.00	70.980	0.15	2.20
	70.812	0.36	0.50	5.33	70.770	0.27	4.21	70.800	0.23	3.19	70.900	0.19	2.83	70.940	0.11	1.47
	70.740	0.29	0.40	5.00	70.730	0.23	4.00	70.760	0.19	3.11	70.860	0.15	2.65	70.920	0.09	1.42
	70.668	0.22	0.30	4.40	70.690	0.19	3.74	70.720	0.15	2.80	70.820	0.11	2.24	70.900	0.07	1.29
	70.596	0.14	0.20	3.88	70.650	0.15	3.54	70.680	0.11	2.71	70.800	0.09	2.08	70.880	0.05	1.29
	70.560	0.11	0.15	3.85	70.610	0.11	3.27	70.660	0.09	2.49	70.780	0.07	1.96	70.860	0.03	1.29
	70.524	0.07	0.10	3.19	70.590	0.09	3.08	70.640	0.07	2.31	70.760	0.05	1.87	70.840	0.01	1.23
	70.488	0.04	0.05	2.74	70.570	0.07	2.86	70.620	0.05	2.20	70.740	0.03	1.63			
	70.462	0.01	0.01	2.45	70.550	0.05	2.85	70.600	0.03	1.96	70.720	0.01	1.50			
	70.452	0.00	0.00		70.530	0.03	2.35	70.580	0.01	0.00						
					70.510	0.01	2.27									
	Average Velocity			4.93			4.08			3.35			2.80			2.28
	71.148	0.71	1.00		71.148	0.62		71.148	0.576		71.148	0.398		71.148	0.253	
X=130'	71.076	0.64	0.90	6.06	71.100	0.57	5.17	71.082	0.510	4.29	71.100	0.350	3.88	71.085	0.190	3.00
	71.006	0.57	0.80	5.70	71.030	0.50	5.17	70.982	0.410	3.88	71.060	0.310	3.88	71.045	0.150	2.80
	70.934	0.50	0.70	5.63	70.930	0.40	5.00	70.882	0.310	3.65	71.020	0.270	3.65	71.005	0.110	2.65
	70.863	0.43	0.60	5.40	70.830	0.30	4.86	70.842	0.270	3.42	70.980	0.230	3.47	70.985	0.090	2.30
	70.791	0.36	0.50	5.17	70.790	0.26	4.48	70.802	0.230	3.27	70.940	0.190	3.16	70.965	0.070	2.24
	70.720	0.29	0.40	4.83	70.750	0.22	4.29	70.762	0.190	3.22	70.900	0.150	2.89	70.945	0.050	1.87
	70.649	0.21	0.30	4.46	70.710	0.18	4.00	70.722	0.150	2.77	70.860	0.110	2.74	70.925	0.030	1.42
	70.578	0.14	0.20	4.09	70.670	0.14	3.83	70.682	0.110	2.49	70.840	0.090	2.62	70.905	0.010	0.50
	70.542	0.11	0.15	3.42	70.630	0.10	3.47	70.662	0.090	2.27	70.820	0.070	2.50			
	70.506	0.07	0.10	2.80	70.610	0.08	3.32	70.642	0.070	1.92	70.800	0.050	2.35			
	70.471	0.04	0.05	2.58	70.590	0.06	3.08	70.622	0.050	1.80	70.780	0.030	2.00			
	70.445	0.01	0.01	1.83	70.570	0.04	2.74	70.602	0.030	1.00	70.760	0.010	1.73			
	70.435	0.00	0.00		70.550	0.02	2.52	70.582	0.010	0.71						
					70.530	0.00	2.04									
	Average Velocity			4.82			4.40			3.22			3.11			2.39
	71.152	0.72	1.00		71.152	0.62		71.152	0.54		71.152	0.40		71.155	0.28	
X=140'	71.080	0.65	0.90	6.20	71.100	0.57	5.30	71.120	0.51	4.88	71.100	0.35	4.40	71.104	0.23	3.92
	71.008	0.57	0.80	5.92	71.035	0.51	5.17	71.020	0.41	4.86	71.060	0.31	4.48	71.064	0.19	3.83
	70.937	0.50	0.70	5.63	70.935	0.41	5.00	70.920	0.31	4.29	71.020	0.27	4.29	71.024	0.15	3.65
	70.865	0.43	0.60	5.40	70.835	0.31	4.83	70.880	0.27	4.29	70.980	0.23	4.23	70.984	0.11	3.19
	70.794	0.36	0.50	5.17	70.795	0.27	4.75	70.840	0.23	3.96	70.940	0.19	4.04	70.964	0.09	2.92
	70.722	0.29	0.40	4.83	70.755	0.23	4.64	70.800	0.19	3.88	70.900	0.15	3.79	70.944	0.07	2.65
	70.650	0.22	0.30	4.65	70.715	0.19	4.32	70.760	0.15	3.54	70.860	0.11	3.59	70.924	0.05	2.24
	70.579	0.14	0.20	3.90	70.675	0.15	3.90	70.720	0.11	3.29	70.840	0.09	3.16	70.904	0.03	2.08
	70.543	0.11	0.15	3.77	70.635	0.11	3.77	70.700	0.09	3.22	70.820	0.07	3.00	70.884	0.01	2.08
	70.507	0.07	0.10	3.34	70.615	0.09	3.34	70.680	0.07	2.89	70.800	0.05	2.80			
	70.471	0.04	0.05	2.96	70.595	0.07	3.08	70.660	0.05	1.73	70.780	0.03	2.65			
	70.446	0.01	0.01	2.31	70.575	0.05	2.86	70.640	0.03	0.91	70.760	0.01	2.00			
	70.436	0.00	0.00		70.555	0.03	2.20	70.620	0.01	0.00						
					70.535	0.01	2.04									
	Average Velocity			4.91			4.42			3.78			3.76			3.17

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 30
Q=15 cfs

Bed Slope= 0.01087
Water Surface Slope= 0.01080

Temp= 71 F

Rock size= 1 in.
Thickness= 1.5 in.

Side slope 2:1

	Location Y=6.0'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.187	0.69	1.00		71.187	0.72		71.187	0.58		71.187	0.45		71.187	0.34	
X=120'	71.118	0.62	0.90	6.06	71.150	0.68	4.83	71.115	0.51	4.09	71.147	0.41	3.65	71.160	0.31	3.14
	71.049	0.55	0.80	5.92	70.975	0.51	4.40	71.015	0.41	3.79	71.047	0.31	3.49	71.120	0.27	3.00
	70.981	0.48	0.70	5.78	70.875	0.41	4.29	70.915	0.31	3.63	71.007	0.27	3.24	71.080	0.23	2.95
	70.912	0.41	0.60	5.63	70.775	0.31	3.88	70.875	0.27	3.47	70.967	0.23	3.06	71.040	0.19	2.74
	70.843	0.34	0.50	5.33	70.735	0.27	3.70	70.835	0.23	3.38	70.927	0.19	2.71	71.000	0.15	2.52
	70.775	0.28	0.40	5.17	70.695	0.23	3.70	70.795	0.19	3.34	70.887	0.15	2.42	70.960	0.11	2.04
	70.706	0.21	0.30	4.68	70.655	0.19	3.27	70.755	0.15	3.20	70.847	0.11	2.24	70.940	0.09	1.96
	70.637	0.14	0.20	4.29	70.615	0.15	2.95	70.715	0.11	3.03	70.827	0.09	2.00	70.920	0.07	1.78
	70.603	0.10	0.15	3.88	70.575	0.11	2.74	70.695	0.09	2.92	70.807	0.07	1.83	70.900	0.05	1.63
	70.569	0.07	0.10	3.65	70.555	0.09	2.50	70.675	0.07	2.88	70.787	0.05	1.29	70.880	0.03	1.50
	70.534	0.03	0.05	3.42	70.535	0.07	2.00	70.655	0.05	2.52	70.767	0.03	0.82	70.860	0.01	1.42
	70.510	0.01	0.01	2.24	70.515	0.05	1.00	70.635	0.03	2.45	70.747	0.01	0.58			
	70.500	0.00	0.00		70.495	0.03	0.00	70.615	0.01	2.35						
					70.475	0.01	0.00									
	Average Velocity			5.06			3.68			3.44			2.72			2.41

	Location Y=6.0'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.170	0.74	1.00		71.170	0.70		71.170	0.610		71.170	0.523		71.178	0.308	
X=130'	71.104	0.67	0.90	3.80	71.150	0.68	4.83	71.170	0.610	4.00	71.150	0.495	3.61	71.140	0.270	3.00
	71.029	0.59	0.80	3.59	70.985	0.51	4.66	71.070	0.510	4.29	71.085	0.410	3.38	71.100	0.230	2.97
	70.955	0.52	0.70	3.31	70.885	0.41	4.29	70.970	0.410	4.00	70.985	0.310	2.97	71.060	0.190	2.68
	70.881	0.45	0.60	3.21	70.785	0.31	4.07	70.870	0.310	3.70	70.925	0.270	2.95	71.020	0.150	2.12
	70.807	0.37	0.50	3.11	70.745	0.27	3.88	70.830	0.270	3.42	70.885	0.230	2.65	70.980	0.110	1.78
	70.732	0.30	0.40	3.00	70.705	0.23	3.81	70.790	0.230	3.22	70.845	0.190	2.24	70.960	0.090	1.53
	70.658	0.22	0.30	2.86	70.665	0.19	3.29	70.750	0.190	3.00	70.805	0.150	2.00	70.940	0.070	1.00
	70.584	0.15	0.20	2.27	70.625	0.15	2.97	70.710	0.150	2.71	70.785	0.110	1.00	70.920	0.050	0.71
	70.546	0.11	0.15	2.12	70.585	0.11	2.49	70.670	0.110	2.31	70.745	0.090	0.91	70.900	0.030	0.41
	70.509	0.07	0.10	1.79	70.565	0.09	2.31	70.650	0.090	1.87	70.725	0.070	0.00	70.880	0.010	0.58
	70.472	0.04	0.05	1.80	70.545	0.07	2.04	70.630	0.070	1.29	70.705	0.050	0.00			
	70.445	0.01	0.01	1.39	70.525	0.05	1.47	70.610	0.050	1.00	70.685	0.030	0.00			
	70.435	0.00	0.00		70.505	0.03	0.59	70.590	0.030	0.82	70.665	0.010	0.00			
					70.485	0.01	0.41	70.570	0.010	0.58						
	Average Velocity			4.00			3.74			3.24			2.33			2.00

	Location Y=6.0'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.175	0.66	1.00		71.175	0.64		71.175	0.530		71.175	0.385		71.175	0.305	
X=140'	71.160	0.59	0.90	5.92	71.140	0.61	5.17	71.135	0.490	4.66	71.140	0.350	4.29	71.140	0.270	3.58
	71.044	0.52	0.80	5.78	71.040	0.51	5.17	71.035	0.410	4.66	71.100	0.310	4.29	71.100	0.230	3.54
	70.978	0.46	0.70	5.63	70.940	0.41	4.83	70.935	0.310	4.29	71.060	0.270	4.08	71.060	0.190	3.37
	70.913	0.39	0.60	5.48	70.840	0.31	4.48	70.915	0.270	4.00	71.020	0.230	3.88	71.020	0.150	3.00
	70.847	0.33	0.50	5.17	70.800	0.27	4.27	70.875	0.230	3.88	70.980	0.190	3.70	70.980	0.110	2.68
	70.782	0.26	0.40	5.00	70.760	0.23	4.13	70.835	0.190	3.80	70.940	0.150	3.39	70.960	0.090	2.35
	70.716	0.20	0.30	4.83	70.720	0.19	3.77	70.795	0.150	3.40	70.900	0.110	3.14	70.940	0.070	2.00
	70.651	0.13	0.20	4.40	70.680	0.15	3.27	70.755	0.110	3.03	70.880	0.090	3.16	70.920	0.050	1.63
	70.618	0.10	0.15	4.29	70.640	0.11	3.00	70.735	0.090	2.77	70.860	0.070	2.89	70.900	0.030	1.53
	70.585	0.06	0.10	3.65	70.620	0.09	2.83	70.715	0.070	2.71	70.840	0.050	2.49	70.880	0.010	1.36
	70.553	0.03	0.05	3.42	70.600	0.07	2.82	70.695	0.050	2.31	70.820	0.030	2.24			
	70.530	0.01	0.01	0.58	70.580	0.05	2.31	70.675	0.030	2.08	70.800	0.010	2.49			
	70.520	0.00	0.00		70.560	0.03	1.60	70.655	0.010	1.87						
					70.540	0.01	1.42									
	Average Velocity			4.97			4.13			3.80			3.49			2.75

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 40 Q=20 cfs	Bed Slope= 0.00000 Water Surface Slope= 0.00000	Temp= 70 F	Rock size= 1 in. Thickness= 1.5 in.	Side slope 2:1

	Location Y=6.0'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'			Location Y=2.8'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.302	0.85	1.00		71.302	0.81		71.302	0.74		71.302	0.62		71.302	0.43		71.302	0.24	
X=120'	71.217	0.77	0.90	6.84	71.255	0.76	5.33	71.275	0.71	4.40	71.290	0.61	4.00	71.285	0.41	3.39	71.295	0.23	2.95
	71.132	0.68	0.80	6.71	71.205	0.71	5.33	71.075	0.51	4.40	71.190	0.51	3.88	71.185	0.31	3.27	71.255	0.19	2.95
	71.047	0.60	0.70	6.46	71.005	0.51	5.00	70.975	0.41	4.00	71.090	0.41	3.70	71.145	0.27	3.00	71.215	0.15	2.89
	70.961	0.51	0.60	6.33	70.905	0.41	4.83	70.875	0.31	4.00	70.990	0.31	3.42	71.105	0.23	2.95	71.175	0.11	2.68
	70.876	0.43	0.50	6.20	70.805	0.31	4.40	70.835	0.27	3.81	70.950	0.27	3.32	71.085	0.19	2.65	71.155	0.09	2.52
	70.791	0.34	0.40	5.70	70.765	0.27	4.08	70.795	0.23	3.54	70.910	0.23	3.22	71.025	0.15	2.38	71.135	0.07	2.42
	70.706	0.26	0.30	5.17	70.725	0.23	3.90	70.755	0.19	3.32	70.870	0.19	2.95	70.985	0.11	2.12	71.115	0.05	2.12
	70.620	0.17	0.20	4.86	70.685	0.19	3.54	70.715	0.15	2.95	70.830	0.15	2.52	70.965	0.08	2.04	71.095	0.03	2.04
	70.578	0.13	0.15	4.29	70.645	0.15	3.16	70.675	0.11	2.85	70.790	0.11	2.20	70.945	0.07	2.00	71.075	0.01	1.96
	70.535	0.08	0.10	3.85	70.605	0.11	2.55	70.655	0.08	2.31	70.770	0.08	1.96	70.925	0.05	1.78			
	70.493	0.04	0.05	3.42	70.585	0.08	2.31	70.635	0.07	2.08	70.750	0.07	1.58	70.905	0.03	1.73			
	70.480	0.01	0.01	3.17	70.565	0.07	2.16	70.615	0.05	1.16	70.730	0.05	1.23	70.885	0.01	1.73			
	70.450	0.00	0.00		70.545	0.05	1.96	70.595	0.03	0.00	70.710	0.03	1.16						
					70.525	0.03	1.58	70.575	0.01	0.00	70.690	0.01	1.08						
					70.505	0.01	0.91												
		Average Velocity		5.67			4.25			3.61			3.10			2.64			2.51
	71.305	0.88	1.00		71.305	0.84		71.305	0.71		71.305	0.62		71.305	0.40		71.305	0.27	
X=130'	71.217	0.81	0.90	6.50	71.200	0.81	5.17	71.200	0.68	4.40	71.290	0.60	3.70	71.285	0.38	3.70	71.285	0.26	2.97
	71.128	0.72	0.80	6.33	71.100	0.71	5.17	71.110	0.51	4.29	71.200	0.51	3.51	71.215	0.31	3.60	71.265	0.23	2.97
	71.040	0.63	0.70	6.06	70.900	0.51	4.83	71.010	0.41	4.00	71.100	0.41	3.37	71.175	0.27	3.34	71.225	0.19	2.86
	70.952	0.54	0.60	5.70	70.800	0.41	4.40	70.910	0.31	4.00	71.000	0.31	2.97	71.135	0.23	3.29	71.185	0.15	2.68
	70.864	0.46	0.50	5.40	70.700	0.31	4.29	70.870	0.27	3.92	70.900	0.27	2.80	71.095	0.19	3.00	71.145	0.11	2.35
	70.775	0.36	0.40	5.17	70.740	0.27	4.00	70.830	0.23	3.65	70.920	0.23	2.77	71.055	0.15	2.97	71.125	0.09	2.12
	70.684	0.27	0.30	4.83	70.700	0.23	3.83	70.790	0.19	3.68	70.880	0.19	2.62	71.015	0.11	2.50	71.105	0.07	1.68
	70.590	0.19	0.20	4.29	70.660	0.19	3.63	70.750	0.15	3.29	70.840	0.15	2.27	70.985	0.08	2.45	71.085	0.05	1.42
	70.554	0.14	0.15	3.88	70.620	0.15	3.37	70.710	0.11	3.00	70.800	0.11	1.96	70.975	0.07	2.27	71.065	0.03	1.29
	70.510	0.10	0.10	3.42	70.580	0.11	3.00	70.690	0.08	2.83	70.780	0.08	1.16	70.955	0.05	1.83	71.045	0.01	1.29
	70.466	0.05	0.05	2.80	70.560	0.08	2.83	70.670	0.07	2.55	70.760	0.07	0.58	70.935	0.03	1.58			
	70.432	0.01	0.01	2.50	70.540	0.07	2.42	70.650	0.05	2.42	70.740	0.05	0.00	70.915	0.01	1.00			
	70.422	0.00	0.00		70.520	0.05	1.83	70.630	0.03	1.96	70.720	0.03	0.00						
					70.500	0.03	1.16	70.610	0.01	1.28	70.700	0.01							
					70.480	0.01	0.82												
		Average Velocity		5.21			4.19			3.76			2.83			2.90			2.27
	71.294	0.83	1.00		71.294	0.75		71.294	0.67		71.294	0.53		71.294	0.43		71.294	0.26	
X=140'	71.211	0.75	0.90	6.57	71.255	0.71	5.61	71.235	0.61	4.90	71.250	0.48	4.27	71.250	0.39	4.07	71.250	0.21	3.36
	71.128	0.66	0.80	6.31	71.085	0.51	5.31	71.135	0.51	4.90	71.175	0.41	4.07	71.175	0.31	3.95	71.225	0.19	3.36
	71.046	0.58	0.70	6.18	70.955	0.41	4.90	71.035	0.41	4.82	71.075	0.31	4.07	71.135	0.27	3.62	71.185	0.15	3.28
	70.963	0.50	0.60	6.04	70.865	0.31	4.64	70.935	0.31	4.46	71.035	0.27	3.80	71.095	0.23	3.33	71.145	0.11	3.05
	70.880	0.41	0.50	5.76	70.815	0.27	4.46	70.885	0.27	4.07	70.985	0.23	3.71	71.055	0.19	3.05	71.125	0.08	2.91
	70.797	0.33	0.40	5.46	70.775	0.23	4.27	70.855	0.23	3.95	70.955	0.19	3.30	71.015	0.15	2.70	71.105	0.07	2.73
	70.714	0.25	0.30	4.90	70.735	0.19	4.03	70.815	0.19	3.67	70.915	0.15	3.15	70.975	0.11	2.44	71.085	0.05	2.51
	70.632	0.17	0.20	4.27	70.695	0.15	3.55	70.775	0.15	3.10	70.875	0.11	2.97	70.955	0.08	2.23	71.065	0.03	2.16
	70.590	0.12	0.15	4.07	70.665	0.11	3.15	70.735	0.11	2.44	70.855	0.08	2.82	70.935	0.07	1.52	71.045	0.01	1.82
	70.549	0.08	0.10	3.64	70.635	0.08	2.82	70.715	0.08	1.63	70.835	0.07	2.44	70.915	0.05	1.15			
	70.507	0.04	0.05	2.88	70.615	0.07	2.51	70.695	0.07	0.71	70.815	0.05	2.30	70.895	0.03	1.15			
	70.476	0.01	0.01	2.24	70.595	0.05	2.34	70.675	0.05	0.41	70.795	0.03	2.08	70.875	0.01	1.15			
	70.466	0.00	0.00		70.575	0.03	2.00	70.655	0.03	0.00	70.775	0.01	1.82						
					70.555	0.01	1.73	70.635	0.01	0.00									
		Average Velocity		5.35			4.40			3.82			3.50			2.97			2.90

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 41 Bed Slope= 0.00001 Temp= 70 F Rock size= 1 in. Side slope 2:1
Q=20 cfs Water Surface Slope= 0.00032 Thickness= 1.5 in.

	Location Y=6.0'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'			Location Y=2.8'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.383	0.92	1.00		71.383	0.84		71.383	0.78		71.383	0.62		71.383	0.48		71.383	0.31	
X=120'	71.271	0.83	0.90	6.20	71.320	0.79	4.83	71.315	0.71	4.08	71.320	0.58	3.88	71.295	0.41	3.65	71.325	0.27	3.16
	71.179	0.73	0.80	6.06	71.235	0.71	4.83	71.115	0.51	4.08	71.250	0.51	3.65	71.195	0.31	3.42	71.285	0.23	3.16
	71.087	0.64	0.70	5.92	71.035	0.51	4.65	71.015	0.41	3.88	71.150	0.41	3.42	71.155	0.27	3.16	71.255	0.20	3.16
	70.995	0.55	0.60	5.46	70.935	0.41	4.46	70.915	0.31	3.65	71.050	0.31	3.16	71.115	0.23	2.89	71.205	0.15	2.89
	70.904	0.46	0.50	5.33	70.835	0.31	4.28	70.875	0.27	3.42	71.010	0.27	2.89	71.075	0.19	2.58	71.175	0.12	2.89
	70.812	0.37	0.40	5.00	70.795	0.27	4.28	70.835	0.23	3.16	70.970	0.23	2.58	71.035	0.15	2.24	71.145	0.09	2.58
	70.720	0.28	0.30	4.85	70.755	0.23	4.08	70.795	0.19	2.89	70.930	0.19	2.58	70.995	0.11	2.24	71.125	0.07	2.12
	70.628	0.18	0.20	3.88	70.715	0.19	3.88	70.755	0.15	2.58	70.890	0.15	2.58	70.975	0.09	2.24	71.105	0.05	2.04
	70.582	0.14	0.15	3.65	70.675	0.15	3.42	70.715	0.11	2.24	70.850	0.11	2.24	70.955	0.07	1.83	71.085	0.03	1.96
	70.536	0.09	0.10	3.16	70.635	0.11	2.89	70.695	0.09	2.31	70.830	0.09	2.24	70.935	0.05	1.29	71.065	0.01	1.83
	70.490	0.05	0.05	2.58	70.615	0.09	2.58	70.675	0.07	2.89	70.810	0.07	2.24	70.915	0.03	1.29			
	70.454	0.01	0.01	1.83	70.595	0.07	1.29	70.655	0.05	1.83	70.790	0.05	1.83	70.895	0.01	0.00			
	70.444	0.00	0.00		70.575	0.05	0.00	70.635	0.03	1.83	70.770	0.03	0.00						
					70.555	0.03	0.00	70.615	0.01	1.29	70.750	0.01	0.00						
					70.535	0.01	0.00												
	Average Velocity			4.97			3.98			3.41			2.88			2.73			2.86

	Location Y=6.0'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'			Location Y=2.8'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.343	0.92	1.00		71.343	0.86		71.343	0.72		71.343	0.63		71.343	0.47		71.343	0.28	
X=130'	71.251	0.83	0.90	6.20	71.295	0.81	4.83	71.330	0.71	4.28	71.320	0.61	3.88	71.280	0.41	3.88	71.330	0.27	3.16
	71.159	0.73	0.80	6.06	71.195	0.71	4.65	71.130	0.51	4.08	71.220	0.51	3.65	71.180	0.31	3.65	71.290	0.23	3.16
	71.068	0.64	0.70	5.78	70.995	0.51	4.65	71.030	0.41	3.88	71.120	0.41	3.65	71.140	0.27	3.42	71.250	0.19	3.16
	70.976	0.55	0.60	5.63	70.895	0.41	4.28	70.930	0.31	3.65	71.020	0.31	3.16	71.100	0.23	3.16	71.210	0.15	2.89
	70.884	0.46	0.50	5.33	70.795	0.31	4.08	70.890	0.27	3.65	70.980	0.27	3.16	71.060	0.19	2.89	71.170	0.11	2.89
	70.792	0.37	0.40	5.00	70.755	0.27	4.08	70.850	0.23	3.65	70.940	0.23	2.77	71.020	0.15	2.89	71.150	0.09	2.58
	70.700	0.28	0.30	4.46	70.715	0.23	3.65	70.810	0.19	3.42	70.900	0.19	2.89	70.980	0.11	2.24	71.130	0.07	2.24
	70.608	0.18	0.20	4.08	70.675	0.19	3.42	70.770	0.15	3.42	70.860	0.15	2.58	70.960	0.09	1.83	71.110	0.05	1.83
	70.563	0.14	0.15	3.88	70.635	0.15	3.16	70.730	0.11	3.16	70.820	0.11	1.83	70.940	0.07	1.83	71.090	0.03	1.83
	70.517	0.09	0.10	3.65	70.595	0.11	2.89	70.710	0.09	2.89	70.800	0.09	1.29	70.920	0.05	1.83	71.070	0.01	1.83
	70.471	0.05	0.05	2.89	70.575	0.09	2.24	70.690	0.07	2.58	70.780	0.07	1.29	70.900	0.03	1.29			
	70.435	0.01	0.01	2.24	70.555	0.07	1.83	70.670	0.05	2.24	70.760	0.05	1.29	70.880	0.01	1.83			
	70.425	0.000	0.00		70.535	0.05	1.29	70.650	0.03	2.24	70.740	0.03	1.29						
					70.515	0.03	0.00	70.630	0.01	0.00	70.720	0.01	1.29						
					70.495	0.01	0.00												
	Average Velocity			5.02			3.81			3.88			2.94			2.98			2.64

	Location Y=6.0'				Location Y=4.0'			Location Y=3.7'			Location Y=3.4'			Location Y=3.1'			Location Y=2.8'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.343	0.84	1.00		71.343	0.81		71.343	0.73		71.343	0.53		71.343	0.49		71.343	0.28	
X=140'	71.250	0.76	0.90	6.33	71.300	0.76	5.33	71.325	0.71	4.46	71.325	0.51	4.08	71.320	0.47	4.08	71.330	0.27	3.42
	71.175	0.67	0.80	6.20	71.245	0.71	5.33	71.125	0.51	4.46	71.225	0.41	4.08	71.260	0.41	4.08	71.290	0.23	3.42
	71.088	0.59	0.70	6.06	71.045	0.51	5.00	71.025	0.41	4.08	71.125	0.31	3.88	71.160	0.31	3.88	71.250	0.19	3.42
	71.004	0.51	0.60	5.92	70.945	0.41	4.83	70.925	0.31	3.88	71.085	0.27	3.65	71.120	0.27	3.65	71.210	0.15	3.16
	70.922	0.42	0.50	5.78	70.845	0.31	4.46	70.885	0.27	3.88	71.045	0.23	3.42	71.080	0.23	3.65	71.170	0.11	3.16
	70.837	0.34	0.40	5.33	70.805	0.27	4.28	70.845	0.23	3.42	71.005	0.19	3.42	71.040	0.19	3.42	71.150	0.09	2.89
	70.753	0.25	0.30	5.00	70.765	0.23	4.08	70.805	0.19	3.16	70.965	0.15	3.42	71.000	0.15	2.89	71.130	0.07	2.89
	70.668	0.17	0.20	4.65	70.725	0.19	3.88	70.765	0.15	2.89	70.925	0.11	3.16	70.960	0.11	2.58	71.110	0.05	2.58
	70.627	0.13	0.15	4.46	70.685	0.15	3.65	70.725	0.11	2.58	70.905	0.09	2.89	70.940	0.09	2.24	71.090	0.03	2.58
	70.584	0.08	0.10	4.08	70.645	0.11	3.16	70.705	0.09	2.24	70.885	0.07	2.58	70.920	0.07	2.24	71.070	0.01	2.24
	70.542	0.04	0.05	3.65	70.625	0.09	2.89	70.685	0.07	1.83	70.865	0.05	2.24	70.900	0.05	1.29			
	70.510	0.01	0.01	3.42	70.605	0.07	2.58	70.665	0.05	1.29	70.845	0.03	2.24	70.880	0.03	1.29			
	70.500	0.00	0.00		70.585	0.05	2.24	70.645	0.03	1.29	70.825	0.01	1.83	70.860	0.01	1.29			
					70.565	0.03	1.83	70.625	0.01	1.29									
					70.545	0.01	1.29												
	Average velocity			5.40			4.38			3.52			3.46			3.23			3.00

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 42 | Bed Slope= 0.00085 | Temp= 71 F | Rock size= 1 in. | Side slope 2:1
Q=30 cfs | Water Surface Slope= 0.00711 | | Thickness= 1.5 in. |

	Location Y=6.0'				Location Y=4.0'			Location Y=3.5'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.504	1.16	1.00		71.504	1.07		71.504	0.80	
X=130'	71.470	1.05	0.90	6.55	71.545	1.03	5.73	71.540	0.94	4.47
	71.361	0.93	0.80	6.33	71.420	0.90	5.61	71.415_	0.71	4.83
	71.245	0.81	0.70	6.21	71.220	0.70	5.40	71.215	0.51	4.31
	71.129	0.70	0.60	5.86	71.020	0.50	5.21	71.115	0.41	4.14
	71.012	0.58	0.50	5.40	70.920	0.40	5.07	71.015	0.31	3.97
	70.896	0.47	0.40	5.35	70.820	0.30	4.83	70.975	0.27	3.70
	70.780	0.35	0.30	5.07	70.780	0.26	4.31	70.935	0.23	3.76
	70.664	0.23	0.20	4.83	70.740	0.22	4.14	70.895	0.19	3.57
	70.605	0.17	0.15	4.14	70.700	0.18	3.70	70.855	0.15	3.44
	70.547	0.12	0.10	3.70	70.660	0.14	3.40	70.815	0.11	3.14
	70.488	0.06	0.05	2.87	70.620	0.10	3.07	70.795	0.09	2.83
	70.441	0.01	0.01	1.00	70.600	0.08	2.70	70.775	0.07	2.30
	70.431	0.00	0.00		70.580	0.06	2.30	70.755	0.05	1.36
					70.560	0.04	1.85	70.735	0.03	0.53
					70.540	0.02	0.76	70.715	0.01	0.38
					70.520	0.00	0.38			
	Average Velocity			5.29			4.70			3.86

	Location Y=3.0'			Location Y=2.5'			Location Y=2.0'		
	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.504	0.66		71.504	0.30		71.504	0.16	
X=130'	71.520	0.59	4.31	71.520	0.31	3.70	71.520	0.09	1.73
	71.440	0.51	4.14	71.480	0.27	3.78	71.505	0.07	1.80
	71.340	0.41	3.78	71.440	0.23	3.59	71.485	0.05	1.56
	71.240	0.31	3.59	71.400	0.19	3.38	71.465	0.03	1.56
	71.200	0.27	3.44	71.360	0.15	3.06	71.445	0.01	1.56
	71.160	0.23	3.14	71.320	0.11	2.80			
	71.120	0.19	2.98	71.300	0.09	2.73			
	71.080	0.15	2.78	71.280	0.07	2.59			
	71.040	0.11	2.54	71.260	0.05	2.33			
	71.020	0.09	2.27	71.240	0.03	2.11			
	71.000	0.07	2.06	71.220	0.01	2.07			
	70.980	0.05	1.73						
	70.960	0.03	1.51						
	70.940	0.01	0.00						
	Average Velocity		3.33			3.12			1.56

	Location Y=6.0'				Location Y=4.0'			Location Y=3.5'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.500	1.17	1.00		71.590	1.11		71.500	0.95	
X=140'	71.481	1.05	0.90	6.55	71.540	1.06	5.81	71.555	0.91	4.70
	71.364	0.93	0.80	6.21	71.395	0.91	5.61	71.355	0.71	4.83
	71.247	0.82	0.70	6.10	71.195	0.71	5.40	71.155	0.51	4.31
	71.131	0.70	0.60	5.86	70.995	0.51	5.07	71.055	0.41	3.70
	71.014	0.58	0.50	5.61	70.895	0.41	4.70	70.955	0.31	3.83
	70.897	0.47	0.40	5.35	70.795	0.31	4.14	70.915	0.27	3.59
	70.780	0.35	0.30	4.93	70.755	0.27	3.97	70.875	0.23	3.32
	70.664	0.23	0.20	4.14	70.715	0.23	3.78	70.835	0.19	3.16
	70.605	0.17	0.15	3.78	70.675	0.19	3.50	70.795	0.15	2.90
	70.547	0.12	0.10	3.16	70.635	0.15	3.38	70.755	0.11	2.30
	70.488	0.06	0.05	2.87	70.595	0.11	3.02	70.735	0.09	2.00
	70.440	0.01	0.01	0.00	70.575	0.09	2.54	70.715	0.07	1.77
	70.430	0.00	0.00		70.555	0.07	2.24	70.695	0.05	1.56
					70.535	0.05	1.20	70.675	0.03	1.25
					70.515	0.03	0.00	70.655	0.01	0.53
					70.495	0.01	0.00			
	Average Velocity			5.17			4.80			3.79

	Location Y=3.0'			Location Y=2.5'			Location Y=2.0'		
	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.500	0.71		71.500	0.42		71.500	0.15	
X=140'	71.555	0.67	4.14	71.550	0.37	3.70	71.500	0.11	2.14
	71.400	0.51	3.70	71.490	0.31	3.76	71.540	0.09	2.14
	71.300	0.41	3.67	71.450	0.27	3.46	71.520	0.07	2.11
	71.200	0.31	3.44	71.410	0.23	3.44	71.500	0.05	2.11
	71.160	0.27	3.02	71.370	0.19	3.07	71.400	0.03	2.07
	71.120	0.23	2.83	71.330	0.15	2.98	71.400	0.01	2.07
	71.080	0.19	2.73	71.290	0.11	2.80			
	71.040	0.15	2.42	71.270	0.09	2.75			
	71.000	0.11	2.27	71.250	0.07	2.59			
	70.980	0.09	2.14	71.230	0.05	2.39			
	70.960	0.07	1.96	71.210	0.03	2.24			
	70.940	0.05	1.73	71.190	0.01	2.00			
	70.920	0.03	1.56						
	70.900	0.01	1.36						
	Average Velocity		3.19			3.12			1.97

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 43 — Bed Slope= 0.00087 — Temp= 73 F — Rock size= 1 in. — Side slope 2:1
Q=60 cfs — Water Surface Slope= 0.00482 — Thickness= 1.5 in.

	Location Y=6.0'				Location Y=4.0'			Location Y=3.5'			Location Y=3.0'			Location Y=2.5'			Location Y=2.0'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.719	1.28	1.00		71.719	1.23		71.719	1.03		71.719	0.82		71.719	0.50		71.719	0.25	
X=120'	71.580	1.16	0.90	6.21	71.650	1.16	4.93	71.650	0.96	4.14	71.650	0.75	3.80	71.625	0.41	3.30	71.655	0.19	2.38
	71.462	1.03	0.80	6.10	71.600	1.11	4.78	71.600	0.91	4.14	71.611	0.71	3.47	71.525	0.31	3.16	71.615	0.15	2.36
	71.333	0.90	0.70	5.86	71.400	0.91	5.21	71.400	0.71	3.97	71.411	0.51	3.10	71.485	0.27	2.90	71.575	0.11	1.80
	71.205	0.77	0.60	5.61	71.200	0.71	5.07	71.200	0.51	3.97	71.311	0.41	2.83	71.445	0.23	2.95	71.555	0.09	1.80
	71.077	0.64	0.50	5.36	71.000	0.51	4.63	71.100	0.41	3.70	71.211	0.31	2.59	71.405	0.19	2.73	71.535	0.07	1.77
	70.948	0.51	0.40	4.93	70.900	0.41	4.47	71.000	0.31	3.67	71.171	0.27	2.45	71.365	0.15	2.56	71.515	0.05	1.60
	70.820	0.38	0.30	4.63	70.800	0.31	4.14	70.960	0.27	3.49	71.131	0.23	2.30	71.325	0.11	2.27	71.495	0.03	1.46
	70.692	0.26	0.20	4.14	70.760	0.27	3.97	70.920	0.23	3.42	71.091	0.19	2.07	71.305	0.09	2.14	71.475	0.01	1.25
	70.628	0.19	0.15	3.70	70.720	0.23	3.70	70.880	0.19	3.16	71.051	0.15	1.77	71.285	0.07	1.93			
	70.563	0.13	0.10	3.30	70.680	0.19	3.65	70.840	0.15	2.80	71.011	0.11	1.41	71.265	0.05	1.77			
	70.499	0.06	0.05	2.30	70.640	0.15	3.16	70.800	0.11	2.54	70.991	0.09	1.20	71.245	0.03	1.51			
	70.445	0.01	0.01	1.00	70.600	0.11	2.70	70.780	0.09	2.27	70.971	0.07	1.07	71.225	0.01	1.36			
	70.435	0.00	0.00		70.580	0.09	2.45	70.760	0.07	2.11	70.951	0.05	0.85						
					70.560	0.07	2.06	70.740	0.05	1.80	70.931	0.03	0.38						
					70.540	0.05	1.73	70.720	0.03	1.36	70.911	0.01	0.38						
					70.520	0.03	0.93	70.700	0.01	0.65									
					70.500	0.01	0.38												
	Average Velocity			5.00			4.36			3.57			2.50			2.73			1.93

	Location Y=6.0'				Location Y=4.0'			Location Y=3.5'			Location Y=3.0'			Location Y=2.5'			Location Y=2.0'		
	71.711	1.26	1.00		71.711	1.17		71.711	1.07		71.711	0.77		71.711	0.55		71.711	0.28	
X=130'	71.585	1.14	0.90	6.21	71.651	1.11	5.07	71.652	1.01	4.31	71.654	0.71	3.70	71.674	0.51	3.55	71.660	0.23	2.30
	71.460	1.01	0.80	6.10	71.461	0.91	5.21	71.552	0.91	4.14	71.454	0.51	3.30	71.574	0.41	3.32	71.620	0.19	2.33
	71.332	0.88	0.70	6.10	71.251	0.71	5.07	71.352	0.71	3.97	71.354	0.41	3.10	71.474	0.31	3.12	71.580	0.15	2.17
	71.206	0.76	0.60	5.61	71.051	0.51	4.93	71.152	0.51	3.70	71.254	0.31	2.83	71.434	0.27	3.02	71.540	0.11	2.00
	71.080	0.63	0.50	5.36	70.951	0.41	4.63	71.052	0.41	3.76	71.214	0.27	2.78	71.394	0.23	2.90	71.520	0.09	1.80
	70.954	0.50	0.40	5.21	70.851	0.31	4.47	70.952	0.31	3.30	71.174	0.23	2.54	71.354	0.19	2.62	71.500	0.07	1.73
	70.828	0.38	0.30	4.78	70.811	0.27	4.14	70.912	0.27	3.21	71.134	0.19	2.33	71.314	0.15	2.42	71.480	0.05	1.46
	70.701	0.25	0.20	4.31	70.771	0.23	3.97	70.872	0.23	3.23	71.094	0.15	2.11	71.274	0.11	2.14	71.460	0.03	1.36
	70.638	0.19	0.15	3.70	70.731	0.19	3.70	70.832	0.19	2.98	71.054	0.11	1.96	71.254	0.09	1.85	71.440	0.01	1.31
	70.575	0.13	0.10	3.50	70.691	0.15	3.70	70.792	0.15	2.54	71.034	0.09	1.77	71.234	0.07	1.73			
	70.512	0.06	0.05	2.93	70.651	0.11	3.36	70.752	0.11	2.36	71.014	0.07	1.80	71.214	0.05	1.36			
	70.458	0.01	0.01	2.30	70.631	0.09	3.21	70.732	0.09	2.00	70.994	0.05	1.46	71.194	0.03	1.07			
	70.449	0.00	0.00		70.611	0.07	2.93	70.712	0.07	0.53	70.974	0.03	1.07	71.174	0.01	0.38			
					70.591	0.05	2.73	70.692	0.05	0.38	70.954	0.01	0.93						
					70.571	0.03	2.17	70.672	0.03	0.00									
					70.551	0.01	1.65	70.652	0.01	0.00									
	Average Velocity			5.13			4.57			3.43			2.83			2.72			1.94

	Location Y=6.0'				Location Y=4.0'			Location Y=3.5'			Location Y=3.0'			Location Y=2.5'			Location Y=2.0'		
	71.714	1.27	1.00		71.714	1.20		71.714	1.05		71.714	0.81		71.714	0.56		71.714	0.32	
X=140'	71.587	1.14	0.90	6.21	71.635	1.12	5.21	71.675	1.01	4.47	71.615	0.71	3.76	71.660	0.51	3.65	71.662	0.27	2.56
	71.460	1.02	0.80	6.21	71.425	0.92	5.21	71.575	0.91	4.31	71.415	0.51	3.50	71.560	0.41	3.57	71.622	0.23	2.40
	71.333	0.89	0.70	5.90	71.225	0.71	5.07	71.375	0.71	4.31	71.315	0.41	3.23	71.460	0.31	3.30	71.582	0.19	2.33
	71.206	0.76	0.60	5.61	71.035	0.52	4.80	71.175	0.51	4.14	71.215	0.31	2.90	71.420	0.27	3.16	71.542	0.15	1.96
	71.080	0.64	0.50	5.40	70.925	0.42	4.63	71.075	0.41	3.97	71.175	0.27	2.73	71.380	0.23	2.85	71.502	0.11	1.65
	70.953	0.51	0.40	5.36	70.825	0.32	4.31	70.975	0.31	3.70	71.135	0.23	2.73	71.340	0.19	2.78	71.482	0.09	1.56
	70.826	0.38	0.30	4.93	70.785	0.28	4.14	70.935	0.27	3.63	71.095	0.19	2.36	71.300	0.15	2.30	71.462	0.07	1.36
	70.699	0.25	0.20	4.47	70.745	0.24	3.70	70.895	0.23	3.49	71.055	0.15	2.11	71.260	0.11	2.14	71.442	0.05	1.31
	70.635	0.19	0.15	4.31	70.705	0.20	3.76	70.855	0.19	3.27	71.015	0.11	1.80	71.240	0.09	1.77	71.422	0.03	1.20
	70.572	0.13	0.10	3.97	70.665	0.16	3.42	70.815	0.15	3.00	70.995	0.09	1.56	71.220	0.07	1.46	71.402	0.01	0.93
	70.508	0.06	0.05	3.50	70.625	0.12	3.02	70.775	0.11	2.73	70.975	0.07	1.51	71.200	0.05	1.36			
	70.455	0.01	0.01	2.30	70.605	0.10	2.80	70.755	0.09	2.67	70.955	0.05	1.41	71.180	0.03	1.31			
	70.445	0.00	0.00		70.585	0.07	2.07	70.735	0.07	2.40	70.935	0.03	1.13	71.160	0.01	1.00			
					70.565	0.06	2.54	70.715	0.05	2.00	70.915	0.01	1.00						
					70.545	0.04	2.17	70.695	0.03	1.73									
					70.525	0.02	1.81	70.675	0.01	0.53									
	Average Velocity			5.27			4.54			3.80			2.95			2.85			1.93

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 44
Q=30 cfs

Bed Slope= 0.00703
Water Surface Slope= 0.00640

Temp= 74 F

Rock size= 1 in.
Thickness= 1.5 in.

Side slope 2:1

	Location Y=6.0'				Location Y=4.9'			Location Y=3.5'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.663	1.24	1.00		71.663	1.10		71.663	0.96	
X=120'	71.583	1.17	0.90	6.76	71.582	1.11	5.40	71.610	0.91	4.47
	71.415	1.00	0.80	6.44	71.382	0.91	5.61	71.410	0.71	4.31
	71.290	0.87	0.70	6.33	71.182	0.71	5.40	71.210	0.51	4.14
	71.166	0.75	0.60	6.21	70.982	0.51	5.35	71.110	0.41	3.97
	71.042	0.62	0.50	5.73	70.882	0.41	5.07	71.010	0.31	3.78
	70.917	0.50	0.40	5.35	70.782	0.31	4.70	70.970	0.27	3.80
	70.793	0.37	0.30	5.07	70.752	0.27	4.63	70.930	0.23	3.57
	70.668	0.25	0.20	4.31	70.712	0.23	4.14	70.890	0.19	3.55
	70.607	0.19	0.15	3.78	70.672	0.19	3.97	70.850	0.15	3.21
	70.544	0.12	0.10	2.83	70.632	0.15	3.78	70.810	0.11	3.10
	70.482	0.06	0.05	2.38	70.592	0.11	3.25	70.790	0.09	2.80
	70.430	0.01	0.01	1.19	70.572	0.09	3.07	70.770	0.07	2.50
	70.420	0.00	0.00		70.552	0.07	2.73	70.750	0.05	2.27
					70.532	0.05	2.27	70.730	0.03	2.00
					70.512	0.03	1.51	70.710	0.01	1.41
					70.492	0.01	0.85			
	Average Velocity			5.32			4.07			3.83
	71.666	1.25	1.00		71.666	1.12		71.666	0.88	
X=130'	71.531	1.12	0.90	6.76	71.630	1.08	5.21	71.630	0.84	4.83
	71.407	1.00	0.80	6.44	71.445	0.91	5.35	71.400	0.71	4.31
	71.282	0.87	0.70	6.33	71.265	0.71	5.35	71.290	0.51	4.14
	71.157	0.75	0.60	5.90	71.065	0.51	5.07	71.190	0.41	4.14
	71.033	0.62	0.50	5.61	70.965	0.41	5.07	71.090	0.31	3.97
	70.908	0.50	0.40	5.35	70.865	0.31	4.83	71.050	0.27	3.97
	70.784	0.37	0.30	4.78	70.825	0.27	4.47	71.010	0.23	3.78
	70.660	0.25	0.20	4.31	70.785	0.23	4.14	70.970	0.19	3.78
	70.597	0.19	0.15	3.97	70.725	0.19	3.97	70.930	0.15	3.50
	70.535	0.13	0.10	3.78	70.685	0.15	3.78	70.890	0.11	3.40
	70.472	0.06	0.05	3.16	70.645	0.11	3.40	70.870	0.09	3.30
	70.420	0.01	0.01	2.38	70.625	0.09	3.40	70.850	0.07	3.16
	70.410	0.00	0.00		70.605	0.07	2.93	70.830	0.05	3.02
					70.585	0.05	2.80	70.810	0.03	2.98
					70.565	0.03	2.62	70.790	0.01	2.75
					70.545	0.01	2.17			
	Average Velocity			5.38			4.75			3.97
	71.666	1.22	1.00		71.666	1.17		71.666	0.98	
X=140'	71.544	1.10	0.90	6.87	71.610	1.11	5.61	71.590	0.91	4.63
	71.421	0.98	0.80	6.44	71.410	0.91	5.61	71.390	0.71	4.47
	71.299	0.85	0.70	6.44	71.210	0.71	5.40	71.190	0.51	4.31
	71.176	0.73	0.60	6.21	71.010	0.51	5.21	71.090	0.41	3.97
	71.054	0.61	0.50	5.61	70.910	0.41	5.07	70.990	0.31	3.70
	70.932	0.49	0.40	5.40	70.810	0.31	4.63	70.950	0.27	3.78
	70.809	0.37	0.30	5.21	70.770	0.27	4.31	70.910	0.23	3.63
	70.687	0.25	0.20	4.78	70.730	0.23	3.97	70.870	0.19	3.25
	70.626	0.18	0.15	4.31	70.690	0.19	3.78	70.830	0.15	2.93
	70.564	0.12	0.10	3.78	70.650	0.15	3.60	70.790	0.11	2.40
	70.503	0.06	0.05	3.16	70.610	0.11	3.21	70.770	0.09	2.11
	70.452	0.01	0.01	1.00	70.590	0.09	2.75	70.750	0.07	1.00
	70.442	0.00	0.00		70.570	0.07	2.30	70.720	0.05	1.00
					70.550	0.05	2.00	70.708	0.03	0.85
					70.530	0.03	1.95	70.690	0.01	0.00
					70.510	0.01	1.36			
	Average Velocity			5.52			4.82			3.80

	Location Y=3.0'			Location Y=2.5'			Location Y=2.0'		
	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.663	0.75		71.663	0.47		71.663	0.24	
X=120'	71.620	0.71	3.78	71.606	0.41	3.40	71.610	0.19	1.85
	71.420	0.51	3.57	71.506	0.31	3.40	71.570	0.15	1.73
	71.320	0.41	3.21	71.466	0.27	3.25	71.530	0.11	1.80
	71.220	0.31	2.80	71.426	0.23	2.90	71.510	0.09	1.51
	71.180	0.27	2.88	71.386	0.19	2.85	71.490	0.07	1.41
	71.140	0.23	2.36	71.346	0.15	2.51	71.470	0.05	1.36
	71.100	0.19	2.14	71.306	0.11	2.04	71.450	0.03	1.25
	71.060	0.15	1.77	71.286	0.09	1.85	71.430	0.01	1.20
	71.020	0.11	1.41	71.266	0.07	1.38			
	71.000	0.09	0.85	71.246	0.05	0.93			
	70.980	0.07	0.85	71.226	0.03	0.53			
	70.960	0.05	0.85	71.206	0.01	0.38			
	70.940	0.03	0.76						
	70.920	0.01	0.76						
	Average Velocity		2.75			2.02			1.55
	71.666	0.68		71.666	0.47		71.666	0.24	
X=130'	71.630	0.64	3.70	71.605	0.41	3.57	71.610	0.19	2.04
	71.400	0.51	3.70	71.505	0.31	3.34	71.570	0.15	1.80
	71.300	0.41	3.47	71.465	0.27	3.25	71.530	0.11	1.85
	71.290	0.31	3.27	71.415	0.23	3.07	71.510	0.09	1.77
	71.250	0.27	3.21	71.375	0.19	2.85	71.490	0.07	1.80
	71.210	0.23	2.90	71.335	0.15	2.87	71.470	0.05	1.41
	71.170	0.19	2.87	71.295	0.11	2.36	71.450	0.03	1.36
	71.130	0.15	2.51	71.275	0.09	2.14	71.430	0.01	1.36
	71.090	0.11	2.36	71.255	0.07	2.00			
	71.070	0.09	2.27	71.235	0.05	1.81			
	71.050	0.07	2.07	71.215	0.03	1.77			
	71.030	0.05	1.96	71.195	0.01	1.56			
	71.010	0.03	1.93						
	70.990	0.01	1.01						
	Average Velocity		3.11			2.06			1.71
	71.666	0.68		71.666	0.56		71.666	0.23	
X=140'	71.625	0.64	4.14	71.614	0.51	3.70	71.630	0.19	2.45
	71.465	0.51	3.78	71.514	0.41	3.00	71.590	0.15	2.36
	71.365	0.41	3.80	71.414	0.31	3.40	71.550	0.11	2.38
	71.265	0.31	3.35	71.374	0.27	3.05	71.530	0.09	2.07
	71.225	0.27	3.34	71.334	0.23	2.93	71.510	0.07	1.80
	71.215	0.23	3.16	71.294	0.19	2.54	71.490	0.05	1.77
	71.175	0.19	2.90	71.254	0.15	2.06	71.470	0.03	1.51
	71.135	0.15	2.75	71.214	0.11	1.85	71.45-	0.01	1.46
	71.095	0.11	2.40	71.194	0.09	1.13			
	71.075	0.09	2.42	71.174	0.07	0.76			
	71.055	0.07	2.30	71.154	0.05	0.53			
	71.035	0.05	1.93	71.134	0.03	0.38			
	71.015	0.03	1.77	71.114	0.01	0.38			
	70.995	0.01	1.56						
	Average Velocity		3.27			2.71			2.08

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 45 Q=40 cfs | Bed Slope= 0.00082 | Water Surface Slope= 0.00464 | Temp= 72 F | Rock size= 1 in. | Thickness= 1.5 in. | Side slope 2:1

	Location Y=6.0'				Location Y=4.0'			Location Y=3.5'			Location Y=3.0'			Location Y=2.5'			Location Y=2.0'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.900	1.57	1.00		71.900	1.40		71.900	1.30		71.900	1.02		71.900	0.70		71.900	0.39	
X=120'	71.832	1.40	0.90	6.31	71.825	1.31	5.65	71.905	1.21	4.65	71.890	0.91	3.99	71.910	0.61	3.38	71.915	0.31	2.46
	71.676	1.25	0.80	6.31	71.625	1.11	5.65	71.805	1.11	4.65	71.690	0.71	3.70	71.810	0.51	3.30	71.875	0.27	2.41
	71.520	1.00	0.70	6.04	71.425	0.91	5.65	71.605	0.91	4.53	71.490	0.51	3.30	71.710	0.41	3.17	71.835	0.23	2.19
	71.365	0.93	0.60	5.85	71.225	0.71	5.55	71.405	0.71	4.27	71.390	0.41	3.06	71.610	0.31	2.82	71.795	0.19	2.11
	71.200	0.78	0.50	5.65	71.025	0.51	4.80	71.205	0.51	4.13	71.290	0.31	2.72	71.570	0.27	2.50	71.755	0.15	1.79
	71.053	0.62	0.40	5.12	70.925	0.41	4.65	71.105	0.41	3.70	71.250	0.27	2.66	71.530	0.23	2.53	71.715	0.11	1.62
	70.887	0.47	0.30	4.77	70.825	0.31	4.13	71.005	0.31	3.54	71.210	0.23	2.36	71.490	0.19	2.19	71.695	0.09	1.50
	70.742	0.31	0.20	4.27	70.785	0.27	4.13	70.965	0.27	3.30	71.170	0.19	2.11	71.450	0.15	1.94	71.675	0.07	1.31
	70.664	0.23	0.15	3.90	70.745	0.23	3.90	70.925	0.23	3.31	71.130	0.15	1.75	71.410	0.11	1.65	71.655	0.05	1.26
	70.586	0.16	0.10	3.54	70.705	0.19	3.54	70.885	0.19	3.00	71.090	0.11	1.01	71.390	0.09	1.50	71.635	0.03	1.17
	70.508	0.08	0.05	2.82	70.665	0.15	3.10	70.845	0.15	2.74	71.070	0.09	0.83	71.370	0.07	1.30	71.615	0.01	0.83
	70.440	0.01	0.01	1.65	70.625	0.11	2.74	70.805	0.11	2.23	71.050	0.07	0.40	71.350	0.05	1.26			
	70.430	0.00	0.00		70.605	0.09	2.41	70.785	0.09	2.00	71.030	0.05	0.34	71.330	0.03	1.17			
					70.585	0.07	2.13	70.765	0.07	1.65	71.010	0.03	0.34	71.310	0.01	0.80			
					70.565	0.05	1.12	70.745	0.05	1.35	70.990	0.01	0.40						
					70.545	0.03	0.40	70.725	0.03	1.22									
					70.525	0.01	0.40	70.705	0.01	0.50									
	Average Velocity			5.20			4.65			3.00			2.95			2.05			1.82

	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.970	1.53	1.00		71.970	1.47		71.970	1.27		71.970	1.03		71.970	0.60		71.970	0.35	
X=130'	71.817	1.38	0.90	6.40	71.810	1.31	5.65	71.810	1.11	4.77	71.851	0.91	3.90	71.900	0.61	3.54	71.887	0.27	2.57
	71.664	1.22	0.80	6.40	71.610	1.11	5.65	71.610	0.91	4.53	71.651	0.71	3.54	71.700	0.41	3.10	71.847	0.23	2.30
	71.511	1.07	0.70	6.31	71.410	0.91	5.55	71.410	0.71	4.40	71.451	0.51	3.24	71.600	0.31	2.80	71.807	0.19	2.16
	71.358	0.92	0.60	6.13	71.210	0.71	5.34	71.210	0.51	4.13	71.351	0.41	3.04	71.560	0.27	2.76	71.767	0.15	1.75
	71.205	0.77	0.50	5.65	71.010	0.51	4.80	71.110	0.41	3.85	71.251	0.31	2.96	71.520	0.23	2.50	71.727	0.11	0.95
	71.052	0.61	0.40	5.23	70.910	0.41	4.40	71.010	0.31	3.54	71.211	0.27	2.66	71.480	0.19	2.29	71.707	0.09	0.60
	70.899	0.46	0.30	4.80	70.810	0.31	4.40	70.970	0.27	3.30	71.171	0.23	2.41	71.440	0.15	1.91	71.687	0.07	0.80
	70.746	0.31	0.20	4.53	70.770	0.27	3.90	70.930	0.23	3.27	71.131	0.19	2.19	71.400	0.11	1.72	71.667	0.05	0.83
	70.669	0.23	0.15	4.27	70.730	0.23	3.70	70.890	0.19	3.04	71.091	0.15	1.97	71.380	0.09	1.50	71.647	0.03	0.83
	70.592	0.15	0.10	3.54	70.690	0.19	3.70	70.850	0.15	2.85	71.051	0.11	1.30	71.360	0.07	1.30	71.627	0.01	0.75
	70.516	0.08	0.05	3.20	70.650	0.15	3.10	70.810	0.11	2.53	71.031	0.09	0.80	71.340	0.05	1.31			
	70.460	0.01	0.01	2.30	70.610	0.11	2.80	70.790	0.09	2.41	71.011	0.07	0.80	71.320	0.03	1.12			
	70.440	0.00	0.00		70.590	0.09	2.30	70.770	0.07	2.13	70.991	0.05	0.75	71.300	0.01	0.80			
					70.570	0.07	1.65	70.750	0.05	1.79	70.971	0.03	0.50						
					70.550	0.05	1.30	70.730	0.03	0.75	70.951	0.01	0.34						
					70.530	0.03	0.85	70.710	0.01	0.00									
					70.510	0.01	0.40												
	Average Velocity			5.41			4.68			3.04			2.96			2.00			1.74

	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.900	1.50	1.00		71.900	1.40		71.900	1.27		71.900	1.00		71.900	0.62		71.900	0.40	
X=140'	71.835	1.37	0.90	6.31	71.894	1.31	5.75	71.830	1.11	4.77	71.885	0.91	4.27	71.880	0.51	3.65	71.900	0.31	2.80
	71.680	1.22	0.80	6.31	71.694	1.11	5.75	71.630	0.91	4.65	71.685	0.71	3.90	71.780	0.41	3.54	71.860	0.27	2.64
	71.530	1.07	0.70	6.22	71.494	0.91	5.65	71.430	0.71	4.53	71.485	0.51	3.70	71.680	0.31	3.30	71.820	0.23	2.57
	71.378	0.92	0.60	5.94	71.294	0.71	5.34	71.230	0.51	4.40	71.385	0.41	3.20	71.640	0.27	3.30	71.780	0.19	2.41
	71.225	0.76	0.50	5.65	71.094	0.51	5.12	71.130	0.41	4.13	71.285	0.31	3.07	71.600	0.23	3.22	71.740	0.15	2.26
	71.072	0.61	0.40	5.55	70.994	0.41	4.80	71.030	0.31	3.85	71.255	0.27	3.02	71.560	0.19	2.96	71.700	0.11	1.97
	70.920	0.46	0.30	5.55	70.894	0.31	4.53	70.990	0.27	3.30	71.215	0.23	2.90	71.520	0.15	2.86	71.680	0.09	1.79
	70.767	0.30	0.20	4.53	70.854	0.27	4.40	70.950	0.23	3.00	71.175	0.19	2.81	71.480	0.11	2.30	71.660	0.07	1.47
	70.691	0.23	0.15	4.27	70.814	0.23	3.90	70.910	0.19	2.70	71.135	0.15	2.41	71.460	0.09	2.34	71.640	0.05	0.80
	70.615	0.15	0.10	3.70	70.774	0.19	3.90	70.870	0.15	2.46	71.095	0.11	1.82	71.440	0.07	2.21	71.620	0.03	0.50
	70.538	0.08	0.05	3.30	70.734	0.15	3.70	70.830	0.11	2.21	71.075	0.09	1.26	71.420	0.05	2.03	71.600	0.01	0.60
	70.472	0.01	0.01	2.30	70.694	0.11	3.30	70.810	0.09	1.85	71.055	0.07	0.86	71.400	0.03	1.72			
	70.462	0.00	0.00		70.674	0.09	3.12	70.790	0.07	1.50	71.035	0.05	0.40	71.380	0.01	1.51			
					70.654	0.07	2.76	70.770	0.05	1.20	71.015	0.03	0.50						
					70.634	0.05	2.16	70.750	0.03	0.75	70.995	0.01	0.50						
					70.614	0.03	1.65	70.730	0.01	0.00									
					70.594	0.01	1.43												
	Average Velocity			5.44			4.90			3.90			3.26			3.15			2.15

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 46 Bed Slope=0.00162 Temp= 75 F Rock size= 1 in. Side slope 2:1
Q=40 cfs Water Surface Slope= 0.00160 Thickness= 1.5 in.

	Location Y=6.0'				Location Y=4.0'			Location Y=3.4'			Location Y=2.8'			Location Y=2.2'			Location Y=1.6'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.074	1.63	1.00		72.074	1.60		72.074	1.33		72.074	1.05		72.074	0.72		72.074	0.44	
X=120'	71.911	1.47	0.90	6.04	71.965	1.51	5.44	72.002	1.26	4.53	72.031	1.01	3.99	72.025	0.67	3.38	72.015	0.38	2.82
	71.748	1.30	0.80	5.75	71.765	1.31	5.55	71.852	1.11	4.40	71.931	0.91	3.70	71.865	0.51	3.20	71.945	0.31	2.82
	71.585	1.14	0.70	5.94	71.565	1.11	5.44	71.652	0.91	4.40	71.731	0.71	3.38	71.765	0.41	2.82	71.905	0.27	2.82
	71.423	0.98	0.60	5.34	71.365	0.91	5.23	71.452	0.71	4.13	71.531	0.51	3.38	71.665	0.31	2.61	71.865	0.23	2.61
	71.260	0.82	0.50	5.01	71.165	0.71	4.88	71.252	0.51	3.99	71.431	0.41	3.02	71.625	0.27	2.61	71.825	0.19	2.39
	71.097	0.65	0.40	4.40	70.965	0.51	4.40	71.152	0.41	3.99	71.331	0.31	2.82	71.585	0.23	2.39	71.785	0.15	2.13
	70.934	0.49	0.30	4.13	70.865	0.41	4.13	71.052	0.31	3.70	71.291	0.27	2.61	71.545	0.19	2.39	71.745	0.11	1.85
	70.771	0.33	0.20	3.70	70.765	0.31	3.70	71.012	0.27	3.54	71.251	0.23	2.61	71.505	0.15	2.13	71.725	0.09	1.85
	70.685	0.24	0.15	3.20	70.745	0.27	3.38	70.972	0.23	3.38	71.211	0.19	2.61	71.465	0.11	2.13	71.705	0.07	1.51
	70.605	0.16	0.10	2.61	70.705	0.23	3.20	70.932	0.19	3.20	71.171	0.15	2.39	71.445	0.09	1.85	71.685	0.05	1.51
	70.525	0.08	0.05	1.07	70.665	0.19	2.82	70.892	0.15	2.82	71.131	0.11	2.13	71.425	0.07	1.85	71.665	0.03	1.51
	70.455	0.01	0.01	1.07	70.625	0.15	2.39	70.852	0.11	2.39	71.111	0.09	2.13	71.405	0.05	1.51	71.645	0.01	1.07
	70.445	0.00	0.00		70.585	0.11	2.13	70.832	0.09	2.13	71.091	0.07	1.85	71.385	0.03	1.51			
					70.565	0.09	1.85	70.812	0.07	1.85	71.071	0.05	1.85	71.365	0.01	1.07			
					70.545	0.07	1.51	70.792	0.05	1.85	71.051	0.03	1.51						
					70.525	0.05	1.07	70.772	0.03	1.85	71.031	0.01	1.51						
					70.505	0.03	1.07	70.752	0.01	1.07									
					70.485	0.01	0.00												
	Average Velocity			4.57			4.52			3.07			3.08			2.65			2.31
	72.056	1.66	1.00		72.056	1.55		72.056	1.34		72.056	1.06		72.056	0.73		72.056	0.44	
X=130'	71.889	1.49	0.90	6.13	72.020	1.51	5.34	72.030	1.31	4.40	72.022	1.03	3.85	72.032	0.71	3.38	72.030	0.41	2.82
	71.726	1.33	0.80	5.94	71.820	1.31	5.34	71.830	1.11	4.40	71.902	0.91	3.70	71.832	0.51	3.02	71.990	0.37	2.82
	71.559	1.16	0.70	5.85	71.620	1.11	5.44	71.630	0.91	4.27	71.702	0.71	3.38	71.732	0.41	3.02	71.950	0.33	2.61
	71.392	1.00	0.60	5.85	71.420	0.91	5.12	71.430	0.71	4.13	71.502	0.51	3.20	71.632	0.31	2.61	71.910	0.29	2.13
	71.225	0.83	0.50	5.12	71.220	0.71	4.77	71.230	0.51	3.85	71.402	0.41	3.02	71.592	0.27	2.61	71.870	0.25	1.85
	71.060	0.66	0.40	4.88	71.020	0.51	4.40	71.130	0.41	3.70	71.302	0.31	3.02	71.552	0.23	2.39	71.730	0.11	1.07
	70.893	0.50	0.30	4.77	70.920	0.41	4.40	71.030	0.31	3.38	71.262	0.27	2.82	71.512	0.19	2.13	71.710	0.09	0.60
	70.727	0.33	0.20	4.27	70.820	0.31	4.13	70.990	0.27	3.38	71.222	0.23	2.61	71.472	0.15	1.85	71.690	0.07	0.48
	70.644	0.25	0.15	3.54	70.780	0.27	3.85	70.950	0.23	3.02	71.182	0.19	2.39	71.432	0.11	1.51	71.670	0.05	0.34
	70.561	0.17	0.10	3.20	70.740	0.23	3.54	70.910	0.19	2.61	71.142	0.15	1.85	71.412	0.09	1.51	71.650	0.03	0.34
	70.478	0.08	0.05	2.39	70.700	0.19	3.38	70.870	0.15	2.39	71.102	0.11	1.85	71.392	0.07	1.07	71.630	0.01	0.00
	70.405	0.01	0.01	1.51	70.660	0.15	2.82	70.830	0.11	1.85	71.082	0.09	1.85	71.372	0.05	1.07			
	70.395	0.00	0.00		70.620	0.11	2.61	70.810	0.09	1.51	71.062	0.07	1.85	71.352	0.03	1.07			
					70.600	0.09	2.61	70.790	0.07	1.51	71.042	0.05	1.51	71.332	0.01	0.00			
					70.580	0.07	2.39	70.770	0.05	1.51	71.022	0.03	1.07						
					70.560	0.05	2.13	70.750	0.03	1.07	71.002	0.01	1.07						
					70.540	0.03	1.85	70.730	0.01	1.07									
					70.520	0.01	0.00												
	Average Velocity			4.95			4.36			3.00			3.01			2.53			1.65
	72.053	1.58	1.00		72.053	1.47		72.053	1.30		72.053	1.05		72.053	0.70		72.053	0.39	
X=140'	71.895	1.42	0.90	6.13	71.895	1.31	5.55	71.960	1.21	4.77	71.910	0.91	4.13	71.965	0.61	3.54	71.960	0.31	3.17
	71.736	1.27	0.80	6.04	71.695	1.11	5.55	71.860	1.11	4.65	71.710	0.71	3.85	71.865	0.51	3.54	71.920	0.27	2.98
	71.578	1.11	0.70	5.94	71.495	0.91	5.55	71.660	0.91	4.65	71.510	0.51	3.38	71.765	0.41	3.38	71.880	0.23	2.82
	71.420	0.95	0.60	5.75	71.295	0.71	5.23	71.460	0.71	4.40	71.410	0.41	3.38	71.665	0.31	3.13	71.840	0.19	2.70
	71.261	0.79	0.50	5.55	71.095	0.51	4.77	71.260	0.51	4.13	71.310	0.31	3.06	71.625	0.27	2.96	71.800	0.15	2.61
	71.103	0.63	0.40	5.23	70.995	0.41	4.65	71.160	0.41	3.85	71.270	0.27	3.00	71.585	0.23	2.90	71.760	0.11	2.41
	70.945	0.47	0.30	4.77	70.895	0.31	4.40	71.060	0.31	3.70	71.230	0.23	2.74	71.545	0.19	2.70	71.740	0.09	2.39
	70.787	0.32	0.20	4.53	70.855	0.27	4.13	71.020	0.27	3.54	71.190	0.19	2.55	71.505	0.15	2.60	71.720	0.07	2.26
	70.707	0.24	0.15	4.27	70.815	0.23	3.85	70.980	0.23	3.38	71.150	0.15	2.08	71.465	0.11	2.11	71.700	0.05	2.19
	70.628	0.16	0.10	3.54	70.775	0.19	3.70	70.940	0.19	3.06	71.110	0.11	1.75	71.445	0.09	2.08	71.680	0.03	2.00
	70.549	0.08	0.05	3.20	70.735	0.15	3.38	70.900	0.15	2.78	71.090	0.09	1.60	71.425	0.07	2.03	71.660	0.01	1.91
	70.486	0.01	0.01	2.82	70.695	0.11	3.38	70.860	0.11	2.48	71.070	0.07	1.51	71.405	0.05	1.50			
	70.470	0.00	0.00		70.675	0.09	3.20	70.840	0.09	2.19	71.050	0.05	1.39	71.385	0.03	1.39			
					70.655	0.07	3.02	70.820	0.07	1.43	71.030	0.03	1.22	71.365	0.01	1.07			
					70.635	0.05	2.82	70.800	0.05	0.40	71.010	0.01	1.17						
					70.615	0.03	2.61	70.780	0.03	0.00									
					70.595	0.01	2.61	70.760	0.01	0.34									
	Average Velocity			5.20			4.87			3.93			3.25			2.86			2.84

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 47 | Bed Slope= 0.00310 | Temp= 75 F | Rock size= 1 in. | Side slope 2:1

Q=60 cfs | Water Surface Slope= 0.00287 | Thickness= 1.5 in.

	Location Y=6.0'				Location Y=4.0'			Location Y=3.3'			Location Y=2.6'			Location Y=1.9'			Location Y=1.2'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.300	1.85	1.00		72.300	1.81		72.300	1.53		72.300	1.15		72.300	0.85		72.300	0.37	
X=120'	72.115	1.66	0.90	5.90	72.195	1.71	5.81	72.185	1.41	5.00	72.255	1.11	4.17	72.265	0.82	3.61	72.235	0.31	2.95
	71.930	1.48	0.80	5.90	71.995	1.51	5.90	72.085	1.31	5.00	72.055	0.91	4.17	72.165	0.72	3.01	72.195	0.27	2.86
	71.745	1.30	0.70	5.81	71.795	1.31	5.90	71.885	1.11	4.80	71.855	0.71	3.61	71.965	0.52	3.13	72.155	0.23	2.74
	71.560	1.11	0.60	5.42	71.595	1.11	5.71	71.685	0.91	4.80	71.655	0.51	3.46	71.865	0.42	3.11	72.115	0.19	2.76
	71.375	0.92	0.50	5.32	71.395	0.91	5.52	71.485	0.71	4.55	71.555	0.41	3.30	71.765	0.32	2.80	72.075	0.15	2.74
	71.190	0.74	0.40	5.11	71.195	0.71	5.00	71.285	0.51	4.43	71.455	0.31	3.13	71.725	0.28	2.86	72.035	0.11	2.19
	71.005	0.55	0.30	4.55	70.995	0.51	4.67	71.185	0.41	4.17	71.415	0.27	3.06	71.685	0.24	2.82	72.015	0.09	2.16
	70.820	0.37	0.20	3.90	70.895	0.41	4.30	71.085	0.31	3.90	71.375	0.23	3.01	71.645	0.20	2.40	71.995	0.07	2.14
	70.728	0.28	0.15	3.30	70.795	0.31	3.90	71.045	0.27	3.76	71.335	0.19	2.86	71.605	0.16	2.36	71.975	0.05	2.06
	70.635	0.19	0.10	2.95	70.755	0.27	3.81	71.005	0.23	3.81	71.295	0.15	2.80	71.565	0.12	2.11	71.955	0.03	2.09
	70.543	0.09	0.05	1.40	70.715	0.23	3.30	70.965	0.19	3.20	71.255	0.11	2.42	71.545	0.10	2.06	71.935	0.01	1.92
	70.460	0.01	0.01	1.04	70.675	0.19	2.97	70.925	0.15	3.01	71.235	0.09	2.00	71.525	0.08	1.82			
	70.450	0.00	0.00		70.635	0.15	2.70	70.885	0.11	2.00	71.215	0.07	1.92	71.505	0.06	1.36			
					70.595	0.11	2.33	70.865	0.09	2.33	71.195	0.05	1.78	71.485	0.04	0.93			
					70.575	0.09	2.01	70.845	0.07	1.87	71.175	0.03	1.32	71.465	0.02	0.57			
					70.555	0.07	1.36	70.825	0.05	1.40	71.155	0.01	1.00						
					70.535	0.05	0.90	70.805	0.03	1.23									
					70.515	0.03	0.33	70.785	0.01	1.14									
					70.495	0.01	0.33												
	Average Velocity			4.80			4.80			4.31			3.30			2.83			2.53
	72.200	1.88	1.00		72.200	1.79		72.200	1.46		72.200	1.20		72.200	0.81		72.200	0.45	
X=130'	72.100	1.69	0.90	5.90	72.205	1.71	5.62	72.135	1.31	4.80	72.200	1.11	4.30	72.185	0.71	3.46	72.150	0.31	2.78
	71.912	1.50	0.80	5.90	72.005	1.51	5.71	71.975	1.15	4.78	72.000	0.91	3.76	71.985	0.51	3.30	72.110	0.27	2.50
	71.720	1.31	0.70	5.81	71.805	1.31	5.71	71.735	0.91	4.78	71.800	0.71	3.61	71.885	0.41	3.13	72.070	0.23	2.42
	71.537	1.13	0.60	5.42	71.605	1.11	5.71	71.535	0.71	4.67	71.600	0.51	3.30	71.785	0.31	3.04	72.030	0.19	2.16
	71.348	0.94	0.50	5.22	71.405	0.91	5.52	71.335	0.51	4.43	71.500	0.41	3.30	71.745	0.27	2.86	71.990	0.15	2.01
	71.161	0.75	0.40	4.80	71.205	0.71	5.00	71.235	0.41	4.30	71.400	0.31	2.90	71.705	0.23	2.60	71.950	0.11	1.60
	70.973	0.56	0.30	4.43	71.005	0.51	4.55	71.175	0.35	3.90	71.360	0.27	2.84	71.665	0.19	2.14	71.930	0.09	3.61
	70.786	0.38	0.20	3.90	70.905	0.41	4.17	71.095	0.27	3.76	71.320	0.23	2.80	71.625	0.15	2.09	71.910	0.07	0.61
	70.692	0.28	0.15	3.61	70.805	0.31	4.17	71.055	0.23	3.76	71.280	0.19	2.40	71.585	0.11	2.01	71.890	0.05	0.57
	70.598	0.19	0.10	3.13	70.765	0.27	3.90	71.015	0.19	3.46	71.240	0.15	2.14	71.565	0.09	1.92	71.870	0.03	0.33
	70.504	0.09	0.05	2.55	70.725	0.23	3.46	70.975	0.15	3.30	71.200	0.11	1.90	71.545	0.07	1.75	71.850	0.01	0.47
	70.420	0.01	0.01	1.40	70.685	0.19	3.30	70.935	0.11	3.00	71.180	0.09	1.90	71.525	0.05	1.71			
	70.410	0.00	0.00		70.645	0.15	3.02	70.915	0.09	2.70	71.160	0.07	1.90	71.505	0.03	1.55			
					70.605	0.11	2.74	70.895	0.07	2.40	71.140	0.05	1.84	71.485	0.01	1.36			
					70.585	0.09	2.30	70.875	0.05	2.30	71.120	0.03	1.55						
					70.565	0.07	2.25	70.855	0.03	2.00	71.100	0.01	1.36						
					70.545	0.05	2.06	70.835	0.01	1.71									
					70.525	0.03	1.80												
					70.505	0.01	1.20												
	Average Velocity			4.84			4.80			4.32			3.20			2.06			2.15
	72.201	1.81	1.00		72.201	1.72		72.201	1.40		72.201	1.15		72.201	0.75		72.201	0.50	
X=140'	72.110	1.63	0.90	5.90	72.080	1.51	5.71	72.110	1.31	5.00	72.155	1.01	4.30	72.200	0.65	3.76	72.195	0.36	2.91
	71.929	1.45	0.80	5.90	71.880	1.31	5.71	71.910	1.11	4.80	72.055	0.91	4.17	72.055	0.51	3.61	72.105	0.31	2.78
	71.748	1.27	0.70	5.81	71.680	1.11	5.71	71.710	0.91	4.80	71.855	0.71	3.90	71.955	0.41	3.30	72.025	0.23	2.53
	71.567	1.09	0.60	5.71	71.480	0.91	5.52	71.510	0.71	4.55	71.655	0.51	3.61	71.855	0.31	3.30	71.985	0.19	2.26
	71.386	0.91	0.50	5.32	71.280	0.71	5.22	71.310	0.51	4.17	71.555	0.41	3.46	71.815	0.27	3.13	71.945	0.15	2.01
	71.204	0.72	0.40	5.00	71.080	0.51	4.78	71.210	0.41	4.04	71.455	0.31	3.30	71.775	0.23	2.86	71.905	0.11	1.75
	71.023	0.54	0.30	4.67	70.980	0.41	4.43	71.110	0.31	3.76	71.415	0.27	3.13	71.735	0.19	2.72	71.885	0.09	1.55
	70.842	0.36	0.20	4.30	70.880	0.31	4.17	71.070	0.27	3.76	71.375	0.23	3.13	71.695	0.15	2.62	71.865	0.07	1.36
	70.752	0.27	0.15	4.04	70.840	0.27	4.06	71.030	0.23	3.30	71.335	0.19	2.95	71.655	0.11	2.53	71.845	0.05	0.87
	70.661	0.18	0.10	3.76	70.800	0.23	3.76	70.990	0.19	3.28	71.295	0.15	2.50	71.635	0.09	2.36	71.825	0.03	0.74
	70.571	0.09	0.05	3.13	70.760	0.19	3.61	70.950	0.15	2.95	71.255	0.11	2.33	71.615	0.07	2.33	71.805	0.01	0.66
	70.490	0.01	0.01	2.00	70.720	0.15	3.30	70.910	0.11	2.50	71.235	0.09	2.00	71.595	0.05	2.21			
	70.480	0.00	0.00		70.680	0.11	3.13	70.890	0.09	2.40	71.215	0.07	1.70	71.575	0.03	2.01			
					70.660	0.09	2.95	70.870	0.07	2.08	71.195	0.05	1.40	71.555	0.01	1.01			
					70.640	0.07	2.78	70.850	0.05	1.80	71.175	0.03	1.28						
					70.620	0.05	2.80	70.830	0.03	1.40	71.155	0.01	1.00						
					70.600	0.03	2.30	70.810	0.01	1.23									
					70.580	0.01	2.16												
	Average Velocity			5.05			4.90			4.25			3.90			3.14			2.26

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 40 Bed Slope= 0.00330 Temp= 70 F Rock size= 1 in. Side slope 2:1
Q=50 cfs Water Surface Slope= 0.00434 Thickness= 1.5 in.

	Location Y=6.0'				Location Y=4.0'			Location Y=3.3'			Location Y=2.6'			Location Y=1.9'			Location Y=1.2'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.202	1.77	1.00		72.202	1.59		72.202	1.51		72.202	2.12		72.202	0.79		72.202	0.36	
X=120'	72.025	1.59	0.90	6.00	72.120	1.51	6.26	72.045	1.35	5.32	72.110	1.03	4.87	72.122	0.71	3.61	72.115	0.27	2.80
	71.860	1.42	0.80	6.52	71.920	1.31	6.26	71.845	1.15	5.22	71.990	0.91	4.43	71.922	0.51	3.30	72.075	0.23	2.70
	71.671	1.26	0.70	6.43	71.720	1.11	6.26	71.645	0.95	5.00	71.790	0.71	3.90	71.822	0.41	2.90	72.035	0.19	2.64
	71.494	1.06	0.60	6.35	71.520	0.91	6.08	71.445	0.75	4.67	71.590	0.51	3.61	71.722	0.31	2.80	71.995	0.15	2.42
	71.317	0.89	0.50	5.90	71.320	0.71	5.90	71.245	0.55	4.30	71.490	0.41	3.61	71.682	0.27	2.58	71.955	0.11	2.26
	71.139	0.71	0.40	5.62	71.120	0.51	5.32	71.145	0.45	4.17	71.390	0.31	3.46	71.642	0.23	2.53	71.935	0.09	2.03
	70.962	0.53	0.30	4.80	71.020	0.41	5.11	71.045	0.35	3.76	71.350	0.27	3.13	71.602	0.19	2.16	71.915	0.07	1.71
	70.785	0.35	0.20	4.55	70.920	0.31	4.80	71.005	0.31	3.30	71.310	0.23	3.01	71.562	0.15	1.87	71.895	0.05	1.20
	70.697	0.27	0.15	3.90	70.880	0.27	4.70	70.965	0.27	3.16	71.270	0.19	2.80	71.522	0.11	1.20	71.875	0.03	1.00
	70.608	0.18	0.10	3.76	70.840	0.23	4.43	70.925	0.23	2.88	71.230	0.15	2.42	71.502	0.09	0.81	71.855	0.01	0.86
	70.520	0.09	0.05	2.95	70.800	0.19	4.17	70.885	0.19	2.40	71.190	0.11	1.92	71.482	0.07	0.47			
	70.441	0.01	0.01	1.40	70.760	0.15	3.90	70.845	0.15	2.16	71.170	0.09	1.62	71.462	0.05	0.33			
	70.431	0.00	0.00		70.720	0.11	3.76	70.825	0.13	2.08	71.150	0.07	1.44	71.442	0.03	0.47			
					70.700	0.09	3.61	70.805	0.11	1.71	71.130	0.05	0.76	71.422	0.01	0.33			
					70.680	0.07	3.46	70.785	0.09	1.40	71.110	0.03	0.00						
					70.660	0.05	3.46	70.765	0.07	1.14	71.090	0.01	0.00						
					70.640	0.03	3.13	70.745	0.05	1.00									
					70.620	0.01	3.13												
	Average Velocity			5.67			5.53			4.21			4.06			2.64			2.28

	Location Y=6.0'				Location Y=4.0'			Location Y=3.3'			Location Y=2.6'			Location Y=1.9'			Location Y=1.2'		
	72.100	1.79	1.00		72.100	1.72		72.100	1.37		72.100	1.05		72.100	0.75		72.100	0.30	
X=130'	72.010	1.61	0.90	6.00	72.002	1.61	6.17	72.075	1.26	5.32	72.063	0.91	4.43	72.100	0.66	3.61	72.070	0.27	2.95
	71.831	1.43	0.80	6.00	71.902	1.51	6.26	71.925	1.11	5.22	71.863	0.71	4.17	71.950	0.51	3.46	72.030	0.23	2.86
	71.652	1.25	0.70	6.52	71.702	1.31	6.26	71.725	0.91	5.00	71.663	0.51	3.76	71.850	0.41	3.30	71.990	0.19	2.40
	71.473	1.07	0.60	6.17	71.502	1.11	6.26	71.525	0.71	4.80	71.563	0.41	3.46	71.750	0.31	3.13	71.950	0.15	2.19
	71.295	0.89	0.50	5.90	71.302	0.91	6.08	71.325	0.51	4.43	71.463	0.31	3.30	71.710	0.27	2.95	71.910	0.11	1.65
	71.116	0.72	0.40	5.52	71.102	0.71	5.62	71.225	0.41	4.17	71.413	0.27	3.23	71.670	0.23	2.76	71.890	0.09	1.06
	70.937	0.54	0.30	5.32	70.902	0.51	5.11	71.125	0.31	4.04	71.373	0.23	3.06	71.630	0.19	2.62	71.870	0.07	0.57
	70.758	0.36	0.20	5.00	70.802	0.41	4.70	71.085	0.27	3.90	71.333	0.19	2.80	71.590	0.15	2.21	71.850	0.05	0.47
	70.669	0.27	0.15	4.67	70.702	0.31	4.06	71.045	0.23	3.76	71.293	0.15	2.60	71.550	0.11	1.92	71.830	0.03	0.57
	70.579	0.18	0.10	3.90	70.742	0.27	3.76	71.005	0.19	3.61	71.253	0.11	2.58	71.530	0.09	1.70	71.810	0.01	0.57
	70.490	0.09	0.05	2.76	70.702	0.23	3.61	70.965	0.15	3.30	71.233	0.09	2.36	71.510	0.07	1.75			
	70.410	0.01	0.01	1.40	70.662	0.19	3.22	70.925	0.11	2.95	71.213	0.07	2.33	71.490	0.05	1.51			
	70.400	0.00	0.00		70.622	0.15	2.78	70.905	0.09	2.76	71.193	0.05	2.33	71.470	0.03	1.40			
					70.582	0.11	2.05	70.885	0.07	2.08	71.173	0.03	2.01	71.450	0.01	1.14			
					70.562	0.09	1.58	70.865	0.05	2.50	71.153	0.01	1.86						
					70.542	0.07	0.81	70.845	0.03	2.19									
					70.522	0.05	0.38	70.825	0.01	1.82									
					70.502	0.03	0.00												
					70.402	0.01	0.00												
	Average Velocity			5.50			5.20			4.40			3.00			2.93			2.11

	Location Y=6.0'				Location Y=4.0'			Location Y=3.3'			Location Y=2.6'			Location Y=1.9'			Location Y=1.2'		
	72.172	1.70	1.00		72.172	1.59		72.172	1.29		72.172	0.97		72.172	0.70		72.172	0.41	
X=140'	71.999	1.52	0.90	6.00	72.075	1.49	6.26	71.995	1.11	5.42	72.010	0.81	4.87	72.085	0.61	4.06	72.075	0.31	3.01
	71.829	1.36	0.80	6.08	71.895	1.31	6.26	71.795	0.91	5.32	71.910	0.71	4.43	71.985	0.51	3.76	72.035	0.27	2.86
	71.660	1.19	0.70	6.43	71.695	1.11	6.35	71.595	0.71	5.11	71.710	0.51	4.17	71.885	0.41	3.46	71.995	0.23	2.74
	71.485	1.01	0.60	6.35	71.495	0.91	6.26	71.395	0.51	4.80	71.610	0.41	3.90	71.785	0.31	3.30	71.955	0.19	2.56
	71.316	0.85	0.50	6.17	71.295	0.71	5.81	71.295	0.41	4.55	71.510	0.31	3.76	71.745	0.27	3.13	71.915	0.15	2.26
	71.146	0.68	0.40	5.61	71.095	0.51	5.22	71.195	0.31	4.43	71.470	0.27	3.76	71.705	0.23	2.95	71.875	0.11	1.92
	70.976	0.50	0.30	5.32	70.995	0.41	5.11	71.155	0.27	4.30	71.430	0.23	3.46	71.665	0.19	2.76	71.855	0.09	1.86
	70.807	0.34	0.20	5.11	70.895	0.31	4.80	71.115	0.23	4.06	71.390	0.19	3.46	71.625	0.15	2.62	71.835	0.07	1.71
	70.722	0.26	0.15	4.67	70.855	0.27	4.87	71.075	0.19	3.90	71.350	0.15	3.30	71.585	0.11	2.47	71.815	0.05	1.48
	70.637	0.17	0.10	4.17	70.815	0.23	4.43	71.035	0.15	3.61	71.310	0.11	3.13	71.565	0.09	2.33	71.795	0.03	1.20
	70.553	0.08	0.05	3.61	70.775	0.19	4.30	70.995	0.11	3.46	71.290	0.09	2.95	71.545	0.07	2.24	71.775	0.01	1.08
	70.488	0.01	0.01	2.58	70.735	0.15	4.30	70.975	0.09	3.30	71.270	0.07	2.76	71.525	0.05	2.01			
	70.470	0.00	0.00		70.695	0.11	3.76	70.955	0.07	3.13	71.250	0.05	2.51	71.505	0.03	1.90			
					70.675	0.09	3.61	70.935	0.05	2.95	71.230	0.03	1.87	71.485	0.01	1.87			
					70.655	0.07	3.46	70.915	0.03	2.76	71.210	0.01	1.82						
					70.635	0.05	3.13	70.895	0.01	2.95									
					70.615	0.03	2.95												
					70.595	0.01	2.76												
	Average Velocity			5.76			5.54			4.75			3.81			3.20			2.37

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 1 | Bed Slope= 0.00301 | Temp= 74 F | Rock size= 0.5 in. | Side slope 2:1

Q= 15 cfs | Water Surface Slope= 0.00203 | Thickness= 0.75 in.

	Location Y=6.00'				Location Y=4.00'			Location Y=3.60'			Location Y=3.20'			Location Y=2.80'			Location Y=2.40'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.495	1.000	1.00		71.495	1.03		71.495	0.92		71.455	0.73		71.455	0.47		71.455	0.24	
X=120'	71.385	0.900	0.90	3.31	71.332	0.91	2.43	71.342	0.81	2.00	71.336	0.61	1.83	71.395	0.41	1.85	71.400	0.19	1.52
	71.235	0.878	0.80	3.21	71.132	0.71	2.43	71.242	0.71	2.01	71.236	0.51	1.79	71.295	0.31	1.66	71.360	0.15	1.44
	71.128	0.760	0.70	3.21	70.932	0.51	2.30	71.042	0.51	2.00	71.136	0.41	1.64	71.255	0.27	1.66	71.320	0.11	1.37
	71.016	0.650	0.60	3.11	70.832	0.41	2.26	70.942	0.41	1.90	71.036	0.31	1.46	71.215	0.23	1.56	71.300	0.09	1.27
	70.906	0.540	0.50	3.00	70.732	0.31	2.15	70.842	0.31	1.86	70.996	0.27	1.46	71.175	0.19	1.52	71.280	0.07	1.19
	70.796	0.430	0.40	2.80	70.692	0.27	2.06	70.802	0.27	1.62	70.956	0.23	1.29	71.135	0.15	1.34	71.260	0.05	1.08
	70.686	0.320	0.30	2.65	70.652	0.23	2.05	70.762	0.23	1.50	70.916	0.19	1.22	71.095	0.11	1.22	71.240	0.03	0.76
	70.577	0.220	0.20	2.54	70.612	0.19	1.95	70.722	0.19	1.29	70.876	0.15	1.16	71.075	0.09	1.11	71.220	0.01	0.57
	70.522	0.165	0.15	2.27	70.572	0.15	1.86	70.682	0.15	1.02	70.836	0.11	0.80	71.055	0.07	0.95			
	70.467	0.110	0.10	1.97	70.532	0.11	1.44	70.642	0.11	0.80	70.816	0.09	0.67	71.035	0.05	0.84			
	70.412	0.055	0.05	1.30	70.512	0.09	1.11	70.622	0.09	0.67	70.796	0.07	0.57	71.015	0.03	0.57			
	70.367	0.000	0.00		70.492	0.07	0.91	70.602	0.07	0.62	70.776	0.05	0.51	70.995	0.01	0.51			
					70.472	0.05	0.72	70.582	0.05	0.57	70.756	0.03	0.51						
					70.452	0.03	0.51	70.562	0.03	0.57	70.736	0.01	0.51						
					70.432	0.01	0.51	70.542	0.01	0.57									
	Average Velocity			2.78			2.12			1.67			1.42			1.43			1.24
	71.451	1.100	1.00		71.451	1.01		71.451	0.88		71.451	0.73		71.451	0.47		71.451	0.27	
X=130'	71.340	0.997	0.90	3.31	71.350	0.91	2.54	71.380	0.81	2.26	71.330	0.61	1.98	71.380	0.41	1.85	71.370	0.19	1.37
	71.229	0.886	0.80	3.21	71.150	0.71	2.37	71.280	0.71	2.24	71.230	0.51	1.92	71.280	0.31	1.60	71.330	0.15	1.32
	71.119	0.776	0.70	3.21	70.950	0.51	2.31	71.080	0.51	2.05	71.130	0.41	1.72	71.250	0.27	1.64	71.290	0.11	1.16
	71.008	0.665	0.60	3.11	70.850	0.41	2.30	70.980	0.41	2.00	71.030	0.31	1.60	71.210	0.23	1.64	71.270	0.09	1.02
	70.897	0.554	0.50	3.00	70.750	0.31	2.17	70.880	0.31	1.93	70.990	0.27	1.46	71.170	0.19	1.41	71.250	0.07	0.88
	70.786	0.443	0.40	2.80	70.710	0.27	2.15	70.840	0.27	1.81	70.950	0.23	1.22	71.130	0.15	1.29	71.230	0.05	0.76
	70.675	0.332	0.30	2.54	70.670	0.23	2.05	70.800	0.23	1.76	70.910	0.19	0.98	71.090	0.11	1.16	71.210	0.03	0.57
	70.565	0.222	0.20	2.27	70.630	0.19	2.01	70.760	0.19	1.65	70.870	0.15	0.72	71.070	0.09	1.00	71.190	0.01	0.51
	70.509	0.166	0.15	2.12	70.590	0.15	1.85	70.720	0.15	1.30	70.830	0.11	0.51	71.050	0.07	0.91			
	70.454	0.111	0.10	1.97	70.550	0.11	1.80	70.680	0.11	1.05	70.810	0.09	0.51	71.030	0.05	0.80			
	70.398	0.055	0.05	1.30	70.530	0.09	1.65	70.660	0.09	0.80	70.790	0.07	0.51	71.010	0.03	0.57			
	70.343	0.000	0.00		70.510	0.07	1.40	70.640	0.07	0.62	70.770	0.05	0.51	70.990	0.01	0.44			
					70.490	0.05	1.32	70.620	0.05	0.44	70.750	0.03	0.44						
					70.470	0.03	1.16	70.600	0.03	0.36	70.730	0.01	0.44						
					70.450	0.01	1.05	70.580	0.01	0.36									
	Average Velocity			2.74			2.10			1.82			1.42			1.42			1.09
	71.463	1.101	1.00		71.463	1.03		71.463	0.87		71.463	0.71		71.463	0.51		71.463	0.16	
X=140'	71.353	0.991	0.90	3.31	71.340	0.91	2.54	71.405	0.81	2.20	71.302	0.61	2.03	71.360	0.41	1.90	71.434	0.13	1.16
	71.243	0.881	0.80	3.21	71.140	0.71	2.50	71.305	0.71	2.17	71.202	0.51	2.01	71.260	0.31	1.79	71.414	0.11	1.05
	71.133	0.771	0.70	3.21	70.940	0.51	2.45	71.105	0.51	2.15	71.102	0.41	1.81	71.220	0.27	1.70	71.394	0.09	0.95
	71.023	0.661	0.60	3.00	70.840	0.41	2.35	71.005	0.41	2.00	71.002	0.31	1.80	71.180	0.23	1.60	71.374	0.07	0.91
	70.913	0.551	0.50	2.80	70.740	0.31	2.27	70.905	0.31	1.90	70.962	0.27	1.62	71.140	0.19	1.44	71.354	0.05	0.88
	70.802	0.440	0.40	2.70	70.700	0.27	2.10	70.865	0.27	1.70	70.922	0.23	1.52	71.100	0.15	1.29	71.334	0.03	0.80
	70.692	0.330	0.30	2.54	70.660	0.23	2.05	70.825	0.23	1.60	70.882	0.19	1.37	71.060	0.11	1.27	71.314	0.01	0.76
	70.582	0.220	0.20	2.27	70.620	0.19	1.74	70.785	0.19	1.60	70.842	0.15	1.27	71.040	0.09	1.22			
	70.527	0.165	0.15	1.97	70.580	0.15	1.60	70.745	0.15	1.44	70.802	0.11	0.98	71.020	0.07	0.91			
	70.472	0.110	0.10	1.70	70.540	0.11	1.28	70.705	0.11	1.30	70.782	0.09	0.72	71.000	0.05	0.36			
	70.417	0.055	0.05	1.30	70.520	0.09	1.22	70.685	0.09	1.27	70.762	0.07	0.57	70.980	0.03	0.36			
	70.362	0.000	0.00		70.500	0.07	0.67	70.665	0.07	1.02	70.742	0.05	0.25	70.960	0.01	0.36			
					70.480	0.05	0.60	70.645	0.05	0.80	70.722	0.03	0.25						
					70.460	0.03	0.60	70.625	0.03	0.80	70.702	0.01	0.25						
					70.440	0.01	0.60	70.605	0.01	0.25									
	Average Velocity			2.80			2.14			1.83			1.56			1.47			0.92

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 2 | Bed Slope= 0.00303 | Temp= 67 F | Rock size= 0.5 in. | Side slope 2:1
Q= 15 cfs | Water Surface Slope= 0.00280 | Thickness= 0.75 in.

	Location Y=6.00'				Location Y=4.00'			Location Y=3.60'			Location Y=3.20'			Location Y=2.80'			Location Y=2.40'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.379	0.979	1.00		71.379	0.93		71.379	0.77		71.379	0.58		71.379	0.41		71.379	0.21	
X=120'	71.281	0.881	0.90	3.50	71.300	0.85	2.86	71.322	0.71	2.27	71.310	0.51	1.97	71.350	0.39	1.79	71.363	0.19	1.19
	71.183	0.783	0.80	3.50	71.160	0.71	2.86	71.122	0.51	2.18	71.210	0.41	1.79	71.275	0.31	1.79	71.323	0.15	1.08
	71.085	0.685	0.70	3.50	70.960	0.51	2.54	71.022	0.41	2.15	71.110	0.31	1.60	71.235	0.27	1.60	71.283	0.11	0.86
	70.987	0.587	0.60	3.50	70.860	0.41	2.54	70.922	0.31	2.14	71.070	0.27	1.39	71.195	0.23	1.64	71.263	0.09	0.72
	70.889	0.489	0.50	3.40	70.760	0.31	2.41	70.882	0.27	1.97	71.030	0.23	1.38	71.155	0.19	1.50	71.243	0.07	0.57
	70.792	0.392	0.40	3.21	70.720	0.27	2.27	70.842	0.23	1.97	70.990	0.19	1.32	71.115	0.15	1.24	71.223	0.05	0.36
	70.694	0.294	0.30	3.00	70.680	0.23	2.12	70.802	0.19	1.79	70.950	0.15	1.29	71.075	0.11	1.22	71.203	0.03	0.44
	70.596	0.196	0.20	2.86	70.640	0.19	1.97	70.762	0.15	1.80	70.910	0.11	1.23	71.055	0.09	1.19	71.183	0.01	0.44
	70.547	0.147	0.15	2.66	70.600	0.15	1.93	70.722	0.11	1.48	70.890	0.09	1.13	71.035	0.07	0.80			
	70.498	0.098	0.10	2.12	70.560	0.11	1.76	70.702	0.09	1.34	70.870	0.07	0.95	71.015	0.05	0.44			
	70.449	0.049	0.05	1.79	70.540	0.09	1.64	70.682	0.07	1.22	70.850	0.05	0.72	70.995	0.03	0.36			
	70.400	0.000	0.00		70.520	0.07	1.58	70.662	0.05	1.06	70.830	0.03	0.62	70.975	0.01	0.36			
					70.500	0.05	1.38	70.642	0.03	0.76	70.810	0.01	0.57						
					70.480	0.03	1.02	70.622	0.01	0.62									
					70.460	0.01	0.44												
	Average Velocity			3.00			2.32			1.93			1.40			1.35			0.77
	71.382	1.047	1.00		71.382	0.92		71.382	0.79		71.382	0.59		71.382	0.39		71.382	0.22	
X=130'	71.278	0.943	0.90	3.50	71.370	0.91	2.70	71.303	0.71	2.41	71.304	0.51	2.00	71.365	0.35	1.97	71.310	0.15	1.00
	71.173	0.838	0.80	3.40	71.175	0.71	2.86	71.103	0.51	2.27	71.204	0.41	2.00	71.305	0.31	1.97	71.270	0.11	0.98
	71.068	0.733	0.70	3.31	70.975	0.51	2.54	71.003	0.41	2.12	71.104	0.31	1.93	71.265	0.27	1.97	71.250	0.09	0.91
	70.963	0.628	0.60	3.21	70.875	0.41	2.41	70.903	0.31	1.97	71.064	0.27	1.90	71.225	0.23	1.93	71.230	0.07	0.80
	70.859	0.524	0.50	3.11	70.775	0.31	2.41	70.863	0.27	1.97	71.024	0.23	1.81	71.185	0.19	1.72	71.210	0.05	0.51
	70.754	0.419	0.40	3.00	70.735	0.27	2.27	70.823	0.23	1.79	70.984	0.19	1.60	71.145	0.15	1.66	71.190	0.03	0.44
	70.649	0.314	0.30	2.70	70.695	0.23	2.12	70.783	0.19	1.60	70.944	0.15	1.38	71.105	0.11	1.41	71.170	0.01	0.36
	70.544	0.209	0.20	2.54	70.655	0.19	2.06	70.743	0.15	1.60	70.904	0.11	0.95	71.085	0.09	1.29			
	70.492	0.157	0.15	2.12	70.615	0.15	2.01	70.703	0.11	1.30	70.884	0.09	0.91	71.065	0.07	1.19			
	70.440	0.105	0.10	1.97	70.575	0.11	1.86	70.683	0.09	1.13	70.864	0.07	0.57	71.045	0.05	1.05			
	70.387	0.052	0.05	1.60	70.555	0.09	1.66	70.663	0.07	0.80	70.844	0.05	0.44	71.025	0.03	0.84			
	70.335	0.000	0.00		70.535	0.07	1.66	70.643	0.05	0.67	70.824	0.03	0.36	71.005	0.01	0.51			
					70.515	0.05	1.50	70.623	0.03	0.57	70.804	0.01	0.36						
					70.495	0.03	1.38	70.603	0.01	0.57									
					70.475	0.01	1.13												
	Average Velocity			2.80			2.35			1.82			1.61			1.50			0.84
	71.405	1.025	1.00		71.405	0.95		71.405	0.82		71.405	0.67		71.405	0.46		71.405	0.21	
X=140'	71.302	0.922	0.90	3.50	71.370	0.91	2.70	71.300	0.71	2.41	71.340	0.61	2.12	71.353	0.41	1.97	71.340	0.15	1.13
	71.200	0.820	0.80	3.40	71.170	0.71	2.86	71.100	0.51	2.27	71.240	0.51	1.97	71.253	0.31	1.97	71.300	0.11	0.91
	71.097	0.717	0.70	3.31	70.970	0.51	2.54	71.000	0.41	1.97	71.140	0.41	1.79	71.213	0.27	1.97	71.280	0.09	0.80
	70.995	0.615	0.60	3.21	70.870	0.41	2.41	70.900	0.31	1.97	71.040	0.31	1.79	71.173	0.23	1.79	71.260	0.07	0.80
	70.892	0.512	0.50	3.11	70.770	0.31	2.27	70.860	0.27	1.79	71.000	0.27	1.60	71.133	0.19	1.38	71.240	0.05	0.62
	70.790	0.410	0.40	3.00	70.730	0.27	2.12	70.820	0.23	1.79	70.960	0.23	1.60	71.093	0.15	1.38	71.220	0.03	0.36
	70.687	0.307	0.30	2.80	70.690	0.23	2.12	70.780	0.19	1.60	70.920	0.19	1.29	71.053	0.11	1.13	71.200	0.01	0.36
	70.585	0.205	0.20	2.54	70.650	0.19	1.97	70.740	0.15	1.52	70.880	0.15	1.05	71.033	0.09	0.80			
	70.534	0.154	0.15	2.41	70.610	0.15	1.79	70.700	0.11	1.37	70.840	0.11	0.67	71.013	0.07	0.51			
	70.482	0.102	0.10	2.12	70.570	0.11	1.60	70.680	0.09	1.05	70.820	0.09	0.44	70.993	0.05	0.44			
	70.431	0.051	0.05	1.60	70.550	0.09	1.44	70.660	0.07	0.80	70.800	0.07	0.36	70.973	0.03	0.44			
	70.380	0.000	0.00		70.530	0.07	1.27	70.640	0.05	0.67	70.780	0.05	0.25	70.953	0.01	0.36			
					70.510	0.05	1.02	70.620	0.03	0.36	70.760	0.03	0.36						
					70.490	0.03	0.62	70.600	0.01	0.36	70.740	0.01	0.36						
					70.470	0.01	0.25												
	Average Velocity			2.92			2.27			1.80			1.50			1.47			0.84

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 3
Q= 15 cfs

Bed Slope= 0.00081
Water Surface Slope= 0.00207

Temp= 70 F

Rock size= 0.5 in.
Thickness= 0.75 in.

Side slope 2:1

	Location Y=6.00'				Location Y=4.00'			Location Y=3.60'			Location Y=3.20'			Location Y=2.80'			Location Y=2.40'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.321	0.981	1.00		71.321	0.90		71.321	0.72		71.321	0.59		71.321	0.40		71.321	0.17	
X=130'	71.223	0.883	0.90	3.76	71.250	0.83	2.78	71.270	0.67	2.41	71.240	0.51	1.97	71.228	0.31	1.79	71.282	0.11	0.91
	71.125	0.785	0.80	3.60	71.130	0.71	2.78	71.100	0.51	2.12	71.140	0.41	1.97	71.180	0.27	1.79	71.242	0.09	0.72
	71.026	0.686	0.70	3.59	70.930	0.51	2.86	71.000	0.41	2.12	71.040	0.31	1.79	71.140	0.23	1.82	71.222	0.07	0.67
	70.928	0.588	0.60	3.50	70.830	0.41	2.86	70.900	0.31	2.12	71.000	0.27	1.80	71.100	0.19	1.41	71.202	0.05	0.36
	70.830	0.490	0.50	3.40	70.730	0.31	2.54	70.860	0.27	1.97	70.960	0.23	1.44	71.060	0.15	1.16	71.182	0.03	0.25
	70.732	0.392	0.40	3.21	70.690	0.27	2.54	70.820	0.23	1.97	70.920	0.19	1.30	71.020	0.11	0.91	71.162	0.01	0.00
	70.634	0.294	0.30	3.00	70.650	0.23	2.41	70.780	0.19	1.79	70.880	0.15	1.05	71.000	0.09	0.57			
	70.536	0.196	0.20	2.86	70.610	0.19	2.12	70.740	0.15	1.72	70.840	0.11	0.51	70.980	0.07	0.25			
	70.487	0.147	0.15	2.41	70.570	0.15	2.03	70.700	0.11	1.68	70.820	0.09	0.36	70.960	0.05	0.25			
	70.438	0.098	0.10	2.12	70.530	0.11	1.74	70.680	0.09	1.62	70.800	0.07	0.36	70.940	0.03	0.00			
	70.389	0.049	0.05	1.38	70.510	0.09	1.50	70.660	0.07	1.50	70.780	0.05	0.00	70.920	0.01	0.00			
	70.340	0.000	0.00		70.490	0.07	1.32	70.640	0.05	1.30	70.760	0.03	0.25						
					70.470	0.05	0.44	70.620	0.03	1.32	70.740	0.01	0.25						
					70.450	0.03	0.25	70.600	0.01	0.91									
					70.430	0.01	0.25												
	Average Velocity			3.10			2.38			1.90			1.41			1.22			0.61

	Location Y=6.00'				Location Y=4.00'			Location Y=3.60'			Location Y=3.20'			Location Y=2.80'			Location Y=2.40'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.356	0.983	1.00		71.366	0.92		71.366	0.79		71.366	0.59		71.356	0.48		71.356	0.23	
X=140'	71.258	0.885	0.90	3.76	71.280	0.84	2.78	71.274	0.71	2.41	71.280	0.51	2.12	71.280	0.40	1.79	71.280	0.15	1.13
	71.160	0.787	0.80	3.59	71.146	0.71	2.78	71.074	0.51	2.27	71.180	0.41	1.97	71.190	0.31	1.79	71.260	0.11	0.91
	71.061	0.688	0.70	3.50	70.946	0.51	2.86	70.974	0.41	2.12	71.080	0.31	1.97	71.150	0.27	1.80	71.220	0.09	0.80
	70.963	0.590	0.60	3.40	70.846	0.41	2.54	70.874	0.31	1.97	71.040	0.27	1.79	71.110	0.23	1.52	71.200	0.07	0.62
	70.865	0.492	0.50	3.31	70.746	0.31	2.54	70.834	0.27	1.97	71.000	0.23	1.79	71.070	0.19	1.22	71.180	0.05	0.25
	70.766	0.393	0.40	3.11	70.706	0.27	2.41	70.794	0.23	1.79	70.960	0.19	1.60	71.030	0.15	0.88	71.160	0.03	0.25
	70.668	0.295	0.30	2.88	70.666	0.23	2.21	70.754	0.19	1.80	70.920	0.15	1.27	70.990	0.11	0.44	71.140	0.01	0.25
	70.570	0.197	0.20	2.86	70.626	0.19	2.11	70.714	0.15	1.34	70.880	0.11	1.05	70.970	0.09	0.36			
	70.521	0.148	0.15	2.41	70.586	0.15	1.97	70.674	0.11	1.02	70.860	0.09	0.90	70.950	0.07	0.25			
	70.471	0.098	0.10	2.12	70.546	0.11	1.68	70.654	0.09	0.87	70.840	0.07	0.76	70.930	0.05	0.00			
	70.422	0.049	0.05	1.80	70.526	0.09	1.52	70.634	0.07	0.36	70.820	0.05	0.44	70.910	0.03	0.00			
	70.373	0.000	0.00		70.506	0.07	1.41	70.614	0.05	0.25	70.800	0.03	0.25	70.890	0.01	0.00			
					70.486	0.05	1.27	70.594	0.03	0.25	70.780	0.01	0.00						
					70.466	0.03	0.88	70.574	0.01	0.00									
					70.446	0.01	0.76												
	Average Velocity			3.05			2.30			1.84			1.80			1.19			0.79

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 5
Q= 15 cfs

Bed Slope= 0.00454
Water Surface Slope= 0.00197

Temp= 88 F

Rock size= 0.5 in.
Thickness= 0.75 in.

Side slope 2:1

	Location Y=6.00'				Location Y=4.00'			Location Y=3.60'			Location Y=3.20'			Location Y=2.80'			Location Y=2.40'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.330	0.923	1.00		71.330	0.90		71.330	0.75		71.330	0.54		71.330	0.32		71.330	0.16	
X=120'	71.254	0.830	0.90	4.81	71.300	0.86	3.40	71.300	0.71	2.70	71.310	0.51	2.41	71.290	0.27	2.12	71.290	0.11	1.27
	71.153	0.738	0.80	4.47	71.150	0.71	3.31	71.100	0.51	2.66	71.210	0.41	2.12	71.250	0.23	2.12	71.270	0.09	1.11
	71.061	0.646	0.70	4.32	70.950	0.51	3.21	71.000	0.41	2.54	71.110	0.31	2.12	71.210	0.19	1.97	71.250	0.07	0.88
	70.969	0.554	0.60	4.00	70.850	0.41	3.00	70.900	0.31	2.54	71.070	0.27	1.97	71.170	0.15	1.79	71.230	0.05	0.72
	70.876	0.461	0.50	4.01	70.750	0.31	2.80	70.860	0.27	2.54	71.030	0.23	1.97	71.130	0.11	1.60	71.210	0.03	0.44
	70.784	0.369	0.40	3.78	70.710	0.27	2.66	70.820	0.23	2.41	70.990	0.19	1.79	71.110	0.09	1.52	71.190	0.01	0.44
	70.692	0.277	0.30	3.90	70.670	0.23	2.41	70.780	0.19	2.12	70.950	0.15	1.60	71.090	0.07	1.44			
	70.600	0.185	0.20	3.50	70.630	0.19	2.27	70.740	0.15	2.12	70.910	0.11	1.60	71.070	0.05	1.19			
	70.553	0.138	0.15	2.80	70.590	0.15	2.12	70.700	0.11	1.79	70.890	0.09	1.30	71.050	0.03	1.00			
	70.507	0.092	0.10	2.86	70.550	0.11	1.97	70.680	0.09	1.80	70.870	0.07	1.24	71.030	0.01	0.90			
	70.461	0.046	0.05	2.54	70.530	0.09	1.74	70.660	0.07	1.44	70.850	0.05	1.13						
	70.415	0.000	0.00		70.510	0.07	[illegible]	70.640	0.05	1.24	70.830	0.03	1.02						
					70.490	0.05	1.22	70.620	0.03	0.67	70.810	0.01	0.72						
					70.470	0.03	1.05	70.600	0.01	0.36									
					70.450	0.01	0.95												
	Average Velocity			3.70			2.79			2.32			1.66			1.71			0.89
	71.341	0.961	1.00		71.341	0.89		71.341	0.71		71.341	0.57		71.341	0.34		71.341	0.18	
X=130'	71.245	0.865	0.90	4.40	71.260	0.81	3.40	71.240	0.61	2.80	71.280	0.51	2.41	71.270	0.27	2.12	71.290	0.13	1.08
	71.149	0.769	0.80	4.32	71.160	0.71	3.31	71.140	0.51	2.70	71.180	0.41	2.41	71.230	0.23	2.12	71.270	0.11	0.91
	71.053	0.673	0.70	4.25	70.960	0.51	3.21	71.040	0.41	2.66	71.080	0.31	2.41	71.190	0.19	1.97	71.250	0.09	0.84
	70.957	0.577	0.60	4.00	70.860	0.41	3.11	70.940	0.31	2.54	71.040	0.27	1.97	71.150	0.15	1.97	71.230	0.07	0.80
	70.861	0.481	0.50	3.93	70.760	0.31	3.00	70.900	0.27	2.54	71.000	0.23	1.78	71.110	0.11	1.79	71.210	0.05	0.62
	70.765	0.385	0.40	3.76	70.720	0.27	2.78	70.860	0.23	2.41	70.960	0.19	1.79	71.090	0.09	1.60	71.190	0.03	0.44
	70.668	0.288	0.30	3.50	70.680	0.23	2.86	70.820	0.19	2.27	70.920	0.15	1.60	71.070	0.07	1.40	71.170	0.01	0.36
	70.572	0.192	0.20	3.31	70.640	0.19	2.54	70.780	0.15	2.27	70.880	0.11	1.30	71.050	0.05	1.11			
	70.524	0.144	0.15	3.00	70.600	0.15	2.41	70.740	0.11	2.12	70.860	0.09	1.11	71.030	0.03	0.76			
	70.476	0.096	0.10	2.86	70.560	0.11	2.27	70.720	0.09	2.03	70.840	0.07	0.91	71.010	0.01	0.51			
	70.428	0.048	0.05	2.41	70.540	0.09	2.12	70.700	0.07	1.78	70.820	0.05	0.72						
	70.380	0.000	0.00		70.520	0.07	2.00	70.680	0.05	1.50	70.800	0.03	0.44						
					70.500	0.05	1.83	70.660	0.03	1.30	70.780	0.01	0.44						
					70.480	0.03	1.86	70.640	0.01	1.32									
					70.460	0.01	1.44												
	Average Velocity			3.70			2.91			2.46			1.60			1.74			0.70
	71.376	0.996	1.00		71.376	0.93	.	71.376	0.78		71.376	0.62		71.376	0.39		71.376	0.22	
X=140'	71.277	0.897	0.90	4.32	71.253	0.81	3.90	71.250	0.65	2.70	71.265	0.51	2.41	71.260	0.27	1.97	71.282	0.11	0.90
	71.177	0.797	0.80	4.25	71.153	0.71	3.40	71.110	0.51	2.66	71.165	0.41	2.27	71.220	0.23	1.78	71.242	0.09	0.80
	71.077	0.697	0.70	4.00	70.953	0.51	3.21	71.010	0.41	2.54	71.065	0.31	2.12	71.180	0.19	1.79	71.222	0.07	0.62
	70.978	0.598	0.60	3.98	70.853	0.41	3.11	70.910	0.31	2.54	71.025	0.27	1.97	71.140	0.15	1.60	71.202	0.05	0.44
	70.878	0.498	0.50	3.88	70.753	0.31	3.00	70.870	0.27	2.27	70.985	0.23	1.97	71.100	0.11	1.60	71.182	0.03	0.51
	70.778	0.398	0.40	3.90	70.713	0.27	2.70	70.830	0.23	2.12	70.945	0.19	1.79	71.080	0.09	1.46	71.162	0.01	0.51
	70.679	0.299	0.30	3.40	70.673	0.23	2.54	70.790	0.19	2.03	70.905	0.15	1.60	71.060	0.07	1.32			
	70.579	0.199	0.20	3.00	70.633	0.19	2.41	70.750	0.15	2.01	70.865	0.11	1.30	71.040	0.05	1.00			
	70.529	0.149	0.15	2.78	70.593	0.15	2.12	70.710	0.11	1.83	70.845	0.09	1.24	71.020	0.03	0.91			
	70.480	0.100	0.10	2.54	70.553	0.11	2.11	70.690	0.09	1.44	70.825	0.07	0.80	71.000	0.01	0.25			
	70.430	0.050	0.05	2.12	70.533	0.09	1.86	70.670	0.07	1.13	70.805	0.05	0.51						
	70.380	0.000	0.00		70.513	0.07	1.64	70.650	0.05	0.80	70.785	0.03	0.44						
					70.493	0.05	1.37	70.630	0.03	0.67	70.765	0.01	0.36						
					70.473	0.03	1.02	70.610	0.01	0.62									
					70.453	0.01	0.57												
	Average Velocity			3.54			2.90			2.20			1.80			1.59			0.79

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 6
Q= 40 cfs

Bed Slope= 0.00306
Water Surface Slope= 0.00241

Temp= 67 F

Rock size= 0.5 in.
Thickness= 0.75 in.

Side slope 2:1

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.00'			Location Y=1.50'			Location Y=1.20'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.083	1.728	1.00		72.083	1.62		72.083	1.33		72.083	0.90		72.083	0.60		72.083	0.30	
X=130'	71.892	1.537	0.90	5.44	71.970	1.51	5.14	72.000	1.26	4.32	71.985	0.91	3.80	71.975	0.51	3.11	72.010	0.23	2.27
	71.721	1.366	0.80	5.38	71.770	1.31	5.14	71.845	1.11	4.32	71.785	0.71	3.50	71.875	0.41	3.00	71.970	0.19	2.12
	71.551	1.196	0.70	5.30	71.570	1.11	5.00	71.645	0.91	4.25	71.585	0.51	3.21	71.775	0.31	2.80	71.930	0.15	2.12
	71.380	1.025	0.60	5.32	71.370	0.91	5.01	71.445	0.71	4.00	71.485	0.41	3.11	71.735	0.27	2.80	71.890	0.11	1.97
	71.209	0.854	0.50	5.26	71.170	0.71	4.81	71.245	0.51	3.86	71.385	0.31	3.00	71.695	0.23	2.70	71.870	0.09	1.79
	71.038	0.683	0.40	5.20	70.970	0.51	4.25	71.145	0.41	3.76	71.345	0.27	3.00	71.655	0.19	2.54	71.850	0.07	1.79
	70.867	0.512	0.30	4.88	70.870	0.41	4.17	71.045	0.31	3.50	71.305	0.23	2.66	71.615	0.15	2.41	71.830	0.05	1.60
	70.697	0.342	0.20	4.54	70.770	0.31	3.93	71.005	0.27	3.31	71.265	0.19	2.41	71.575	0.11	2.12	71.810	0.03	1.32
	70.611	0.256	0.15	3.93	70.730	0.27	3.85	70.965	0.23	3.21	71.225	0.15	2.12	71.555	0.09	2.12	71.790	0.01	0.57
	70.526	0.171	0.10	3.76	70.690	0.23	3.50	70.925	0.19	3.00	71.185	0.11	1.97	71.535	0.07	1.79			
	70.440	0.085	0.05	3.21	70.650	0.19	3.40	70.885	0.15	2.80	71.165	0.09	1.80	71.515	0.05	1.62			
	70.355	0.000	0.00		70.610	0.15	3.21	70.845	0.11	2.54	71.145	0.07	1.13	71.495	0.03	1.39			
					70.570	0.11	2.78	70.825	0.09	2.27	71.125	0.05	0.72	71.475	0.01	1.34			
					70.550	0.09	2.27	70.805	0.07	1.97	71.105	0.03	0.62						
					70.530	0.07	1.97	70.785	0.05	1.79	71.085	0.01	0.57						
					70.510	0.05	1.79	70.765	0.03	1.00									
					70.490	0.03	1.60	70.745	0.01	1.13									
				.	70.470	0.01	1.41												
	Average Velocity			4.85			4.46			3.75			2.96			2.03			1.07
	72.076	1.676	1.00		72.076	1.64		72.076	1.34		72.076	1.01		72.076	0.66		72.076	0.31	
X=140'	71.908	1.508	0.90	5.32	71.945	1.51	5.00	72.045	1.31	4.25	71.975	0.91	3.90	72.030	0.61	3.11	72.035	0.27	1.00
	71.741	1.341	0.80	5.26	71.745	1.31	5.06	71.845	1.11	4.17	71.775	0.71	3.31	71.930	0.51	3.00	71.995	0.23	1.00
	71.573	1.173	0.70	5.26	71.545	1.11	4.95	71.645	0.91	4.17	71.575	0.51	3.00	71.830	0.41	2.80	71.955	0.19	1.00
	71.406	1.006	0.60	5.20	71.345	0.91	4.81	71.445	0.71	3.85	71.475	0.41	2.66	71.730	0.31	2.66	71.915	0.15	1.52
	71.238	0.838	0.50	5.14	71.145	0.71	4.54	71.245	0.51	3.50	71.375	0.31	2.54	71.690	0.27	2.54	71.875	0.11	1.37
	71.070	0.670	0.40	5.01	70.945	0.51	4.32	71.145	0.41	3.40	71.335	0.27	2.41	71.650	0.23	2.27	71.855	0.09	1.32
	70.903	0.503	0.30	4.75	70.845	0.41	4.08	71.045	0.31	3.31	71.295	0.23	2.27	71.610	0.19	1.97	71.835	0.07	1.02
	70.735	0.335	0.20	4.61	70.745	0.31	3.76	71.005	0.27	3.11	71.255	0.19	2.12	71.570	0.15	1.79	71.815	0.05	0.80
	70.651	0.251	0.15	4.25	70.705	0.27	3.40	70.965	0.23	2.80	71.215	0.15	1.97	71.530	0.11	1.60	71.795	0.03	0.80
	70.568	0.168	0.10	4.01	70.665	0.23	3.21	70.925	0.19	2.54	71.175	0.11	1.80	71.510	0.09	1.24	71.775	0.01	0.76
	70.484	0.084	0.05	3.76	70.625	0.19	3.11	70.885	0.15	2.41	71.155	0.09	1.30	71.490	0.07	0.91			
	70.400	0.000	0.00		70.585	0.15	2.78	70.845	0.11	2.27	71.135	0.07	1.13	71.470	0.05	0.62			
					70.545	0.11	2.27	70.825	0.09	2.12	71.115	0.05	0.95	71.450	0.03	0.51			
					70.525	0.09	1.97	70.805	0.07	2.12	71.095	0.03	0.80	71.430	0.01	0.38			
					70.505	0.07	1.78	70.785	0.05	1.97	71.075	0.01	0.57						
					70.485	0.05	1.32	70.765	0.03	1.00									
					70.465	0.03	0.80	70.745	0.01	1.30									
					70.445	0.01	0.38												
	Average Velocity			4.81			4.30			3.55			2.72			2.34			1.34

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 7
Q= 40 cfs

Bed Slope= 0.00204
Water Surface Slope= 0.00170

Temp= 60 F

Rock size= 0.5 in.
Thickness= 0.75 in.

Side slope 2:1

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.60'			Location Y=1.90'			Location Y=1.20'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.116	1.784	1.00		72.116	1.65		72.116	1.44		72.116	1.12		72.116	0.81		72.116	0.42	
X=120'	71.938	1.606	0.90	5.00	72.075	1.61	5.01	71.985	1.31	4.32	72.050	1.06	3.60	72.020	0.71	2.80	72.010	0.31	2.27
	71.759	1.427	0.80	5.01	71.975	1.51	5.01	71.785	1.11	4.32	72.005	1.01	3.50	71.820	0.51	2.86	71.970	0.27	2.12
	71.581	1.249	0.70	5.01	71.775	1.31	4.95	71.585	0.91	4.17	71.905	0.91	3.50	71.720	0.41	2.54	71.930	0.23	1.97
	71.402	1.070	0.60	4.95	71.575	1.11	4.95	71.385	0.71	3.93	71.705	0.71	3.21	71.620	0.31	2.27	71.890	0.19	1.97
	71.224	0.892	0.50	4.80	71.375	0.91	4.81	71.185	0.51	3.80	71.505	0.51	3.11	71.580	0.27	2.12	71.850	0.15	1.60
	71.046	0.714	0.40	4.61	71.175	0.71	4.61	71.085	0.41	3.80	71.405	0.41	3.11	71.540	0.23	1.79	71.810	0.11	1.30
	70.867	0.535	0.30	4.32	70.975	0.51	4.25	70.985	0.31	3.50	71.305	0.31	2.80	71.500	0.19	1.60	71.790	0.09	1.13
	70.689	0.357	0.20	4.17	70.875	0.41	4.01	70.945	0.27	3.40	71.265	0.27	2.06	71.460	0.15	1.11	71.770	0.07	0.82
	70.600	0.268	0.15	3.50	70.775	0.31	3.85	70.905	0.23	3.11	71.225	0.23	2.41	71.420	0.11	1.00	71.750	0.05	0.51
	70.510	0.178	0.10	3.31	70.735	0.27	3.80	70.865	0.19	3.00	71.185	0.19	2.12	71.400	0.09	0.90	71.730	0.03	0.44
	70.421	0.089	0.05	2.54	70.695	0.23	3.50	70.825	0.15	2.86	71.145	0.15	1.97	71.380	0.07	0.72	71.710	0.01	0.44
	70.332	0.000	0.00		70.655	0.19	3.21	70.785	0.11	2.41	71.105	0.11	1.79	71.360	0.05	0.62			
					70.615	0.15	3.00	70.765	0.09	1.97	71.085	0.09	1.30	71.340	0.03	0.62			
					70.575	0.11	2.70	70.745	0.07	1.30	71.065	0.07	1.32	71.320	0.01	0.62			
					70.555	0.09	2.06	70.725	0.05	1.11	71.045	0.05	1.05						
					70.535	0.07	2.54	70.705	0.03	0.80	71.025	0.03	0.57						
					70.515	0.05	2.12	70.685	0.01	0.51	71.005	0.01	0.25						
					70.495	0.03	1.79												
					70.475	0.01	1.13												
	Average Velocity			4.42			4.38			3.70			2.80			2.16			1.66
	72.083	1.740	1.00		72.083	1.67		72.083	1.39		72.083	1.11		72.083	0.76		72.083	0.37	
X=130'	71.909	1.566	0.90	5.14	71.920	1.51	4.95	71.930	1.24	4.25	71.965	0.99	3.60	71.935	0.61	3.00	71.980	0.27	2.41
	71.735	1.392	0.80	5.14	71.720	1.31	4.80	71.800	1.11	4.17	71.885	0.91	3.50	71.835	0.51	2.70	71.940	0.23	2.27
	71.561	1.218	0.70	5.08	71.520	1.11	4.81	71.600	0.91	4.00	71.685	0.71	3.31	71.735	0.41	2.54	71.900	0.19	1.97
	71.387	1.044	0.60	5.01	71.320	0.91	4.75	71.400	0.71	4.01	71.485	0.51	3.11	71.635	0.31	2.12	71.860	0.15	1.60
	71.213	0.870	0.50	4.86	71.120	0.71	4.61	71.200	0.51	3.93	71.385	0.41	2.80	71.595	0.27	1.97	71.820	0.11	1.30
	71.039	0.696	0.40	4.75	70.920	0.51	4.17	71.100	0.41	3.80	71.285	0.31	2.06	71.555	0.23	1.79	71.800	0.09	1.24
	70.865	0.522	0.30	4.40	70.820	0.41	3.93	71.000	0.31	3.31	71.245	0.27	2.41	71.515	0.19	1.60	71.780	0.07	1.02
	70.691	0.348	0.20	4.17	70.720	0.31	3.86	70.960	0.27	3.11	71.205	0.23	2.27	71.475	0.15	1.50	71.760	0.05	0.76
	70.604	0.261	0.15	3.85	70.680	0.27	3.50	70.920	0.23	3.00	71.165	0.19	1.97	71.435	0.11	1.00	71.740	0.03	0.51
	70.517	0.174	0.10	3.50	70.640	0.23	3.40	70.880	0.19	2.80	71.125	0.15	1.80	71.415	0.09	1.00	71.720	0.01	0.51
	70.430	0.087	0.05	2.86	70.600	0.19	3.11	70.840	0.15	2.54	71.085	0.11	1.13	71.395	0.07	0.62			
	70.343	0.000	0.00		70.560	0.15	2.70	70.800	0.11	2.27	71.065	0.09	0.76	71.375	0.05	0.57			
					70.520	0.11	2.41	70.780	0.09	2.12	71.045	0.07	0.62	71.355	0.03	0.62			
					70.500	0.09	2.27	70.760	0.07	1.79	71.025	0.05	0.67	71.335	0.01	0.57			
					70.480	0.07	2.12	70.740	0.05	1.00	71.005	0.03	0.67						
					70.460	0.05	1.97	70.720	0.03	0.57	70.985	0.01	0.00						
					70.440	0.03	1.97	70.700	0.01	0.00									
					70.420	0.01	0.51												
	Average Velocity			4.53			4.27			3.64			2.79			2.21			1.73
	72.078	1.718	1.00		72.078	1.64		72.070	1.31		72.070	1.04		72.078	0.68		72.078	0.34	
X=140'	71.906	1.546	0.90	5.20	71.950	1.51	4.80	71.900	1.21	4.32	71.900	0.91	3.50	71.903	0.51	2.80	71.925	0.19	1.79
	71.734	1.374	0.80	5.08	71.750	1.31	4.80	71.800	1.11	4.32	71.700	0.71	3.40	71.803	0.41	2.70	71.885	0.15	1.79
	71.563	1.203	0.70	5.08	71.550	1.11	4.61	71.600	0.91	4.25	71.500	0.51	3.31	71.703	0.31	2.66	71.845	0.11	1.34
	71.391	1.031	0.60	5.01	71.350	0.91	4.80	71.400	0.71	4.17	71.400	0.41	3.21	71.663	0.27	2.66	71.825	0.09	1.24
	71.219	0.859	0.50	4.95	71.150	0.71	4.54	71.200	0.51	4.01	71.300	0.31	3.00	71.623	0.23	2.41	71.805	0.07	1.05
	71.047	0.687	0.40	4.80	70.950	0.51	4.25	71.100	0.41	3.90	71.310	0.27	2.70	71.583	0.19	2.27	71.785	0.05	0.57
	70.875	0.515	0.30	4.47	70.850	0.41	3.93	71.000	0.31	3.50	71.270	0.23	2.54	71.543	0.15	2.12	71.765	0.03	0.57
	70.704	0.344	0.20	4.32	70.750	0.31	3.80	70.960	0.27	3.50	71.230	0.19	2.12	71.503	0.11	1.80	71.745	0.01	0.51
	70.618	0.258	0.15	3.85	70.710	0.27	3.30	70.920	0.23	3.40	71.190	0.15	1.97	71.483	0.09	1.80			
	70.532	0.172	0.10	3.40	70.670	0.23	3.11	70.880	0.19	3.11	71.150	0.11	1.80	71.463	0.07	1.30			
	70.446	0.086	0.05	2.86	70.630	0.19	2.80	70.840	0.15	3.00	71.130	0.09	1.32	71.443	0.05	1.29			
	70.360	0.000	0.00		70.590	0.15	2.70	70.800	0.11	2.80	71.110	0.07	1.24	71.423	0.03	1.24			
					70.550	0.11	2.41	70.780	0.09	2.70	71.090	0.05	0.90	71.403	0.01	0.80			
					70.530	0.09	2.12	70.760	0.07	2.41	71.070	0.03	0.51						
					70.510	0.07	1.97	70.740	0.05	2.27	71.050	0.01	0.00						
					70.490	0.05	1.30	70.720	0.03	2.12									
					70.470	0.03	1.05	70.700	0.01	1.97									
					70.450	0.01	0.51												
	Average Velocity			4.55			4.28			3.65			2.92			2.42			1.45

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 8 Bed Slope= 0.00119 Temp= 67 F Rock size= 0.5 in. Side slope 2:1
Q= 40 cfs Water Surface Slope= 0.00200 Thickness= 0.75 in.

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.00'			Location Y=1.50'			Location Y=1.20'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.190	1.823	1.00		72.190	1.74		72.190	1.46		72.190	1.13		72.190	0.80		72.190	0.41	
X=120'	72.016	1.641	0.90	4.80	72.070	1.61	4.75	72.065	1.31	4.17	72.080	1.01	3.50	72.110	0.71	3.11	72.085	0.31	2.54
	71.833	1.458	0.80	4.61	71.970	1.51	4.00	71.865	1.11	4.17	71.900	0.91	3.40	71.910	0.51	2.80	72.055	0.27	2.41
	71.651	1.276	0.70	4.61	71.770	1.31	4.08	71.665	0.91	4.00	71.700	0.71	3.21	71.810	0.41	2.86	72.015	0.23	2.27
	71.469	1.094	0.60	4.54	71.570	1.11	4.61	71.465	0.71	3.80	71.500	0.51	3.11	71.710	0.31	2.41	71.975	0.19	2.12
	71.287	0.912	0.50	4.47	71.370	0.91	4.47	71.265	0.51	3.40	71.400	0.41	3.00	71.670	0.27	2.27	71.935	0.15	1.97
	71.104	0.729	0.40	4.17	71.170	0.71	4.17	71.165	0.41	3.31	71.300	0.31	2.70	71.630	0.23	2.12	71.895	0.11	1.79
	70.922	0.547	0.30	3.93	70.970	0.51	3.93	71.065	0.31	3.21	71.340	0.27	2.86	71.590	0.19	1.97	71.875	0.08	1.80
	70.740	0.365	0.20	3.50	70.870	0.41	3.76	71.005	0.27	3.00	71.300	0.23	2.06	71.550	0.15	1.97	71.855	0.07	1.80
	70.649	0.273	0.15	3.40	70.770	0.31	3.50	70.965	0.23	2.78	71.260	0.19	2.41	71.510	0.11	1.46	71.835	0.05	1.37
	70.557	0.182	0.10	3.00	70.730	0.27	3.31	70.925	0.19	2.06	71.220	0.15	2.27	71.490	0.09	1.29	71.815	0.03	1.19
	70.466	0.091	0.05	2.54	70.690	0.23	3.21	70.885	0.15	2.41	71.180	0.11	2.12	71.470	0.07	0.91	71.795	0.01	0.95
	70.375	0.000	0.00		70.650	0.19	3.00	70.845	0.11	2.12	71.160	0.09	1.97	71.450	0.05	0.62			
					70.610	0.15	2.78	70.825	0.09	1.80	71.140	0.07	1.80	71.430	0.03	0.51			
					70.570	0.11	2.54	70.805	0.07	1.56	71.120	0.05	1.29	71.410	0.01	0.51			
					70.550	0.09	2.41	70.785	0.05	0.91	71.100	0.03	0.84						
					70.530	0.07	2.12	70.765	0.03	0.82	71.080	0.01	0.57						
					70.510	0.05	1.97	70.745	0.01	0.38									
					70.490	0.03	1.79												
					70.470	0.01	1.80												
	Average Velocity			4.65			4.08			3.40			2.91			2.30			2.04
	72.150	1.800	1.00		72.180	1.70		72.150	1.41		72.150	1.06		72.150	0.73		72.150	0.32	
X=130'	71.970	1.620	0.90	4.75	72.070	1.61	4.75	72.000	1.26	4.17	72.010	0.91	3.50	72.000	0.57	3.11	72.046	0.21	2.41
	71.787	1.447	0.80	4.80	71.970	1.51	4.00	71.885	1.11	4.00	71.810	0.71	3.40	71.900	0.51	3.00	71.985	0.15	2.27
	71.616	1.266	0.70	4.61	71.770	1.31	4.08	71.685	0.91	3.93	71.610	0.51	3.31	71.800	0.41	2.70	71.965	0.11	2.12
	71.435	1.085	0.60	4.54	71.570	1.11	4.61	71.485	0.71	3.65	71.510	0.41	3.11	71.740	0.31	2.54	71.925	0.08	2.12
	71.255	0.905	0.50	4.40	71.370	0.91	4.40	71.285	0.51	3.50	71.410	0.31	3.11	71.700	0.27	2.41	71.905	0.07	1.97
	71.074	0.724	0.40	4.25	71.170	0.71	4.25	71.155	0.41	3.50	71.370	0.27	2.80	71.660	0.23	2.27	71.885	0.05	1.79
	70.893	0.543	0.30	4.01	70.970	0.51	4.01	71.085	0.31	3.31	71.330	0.23	2.70	71.620	0.19	2.12	71.865	0.03	1.79
	70.712	0.362	0.20	3.80	70.870	0.41	3.93	71.015	0.27	3.21	71.290	0.19	2.86	71.580	0.15	1.97	71.845	0.01	1.80
	70.621	0.271	0.15	3.40	70.770	0.31	3.80	70.975	0.23	2.80	71.250	0.15	2.54	71.540	0.11	1.79			
	70.531	0.181	0.10	3.21	70.730	0.27	3.50	70.935	0.19	2.70	71.210	0.11	2.27	71.520	0.09	1.80			
	70.440	0.090	0.05	2.41	70.690	0.23	3.31	70.895	0.15	2.06	71.190	0.09	2.12	71.500	0.07	1.30			
	70.350	0.000	0.00		70.650	0.19	3.11	70.855	0.11	2.27	71.170	0.07	1.97	71.480	0.05	1.16			
					70.610	0.15	2.80	70.835	0.09	2.27	71.150	0.05	1.79	71.460	0.03	0.95			
					70.570	0.11	2.86	70.815	0.07	2.12	71.130	0.03	1.80	71.440	0.01	0.62			
					70.550	0.09	2.41	70.795	0.05	1.97	71.110	0.01	1.80						
					70.530	0.07	1.97	70.775	0.03	1.79									
					70.510	0.05	1.80	70.755	0.01	1.79									
					70.490	0.03	1.80												
					70.470	0.01	0.82												
	Average Velocity			4.80			4.00			3.50			3.06			2.46			2.14
	72.140	1.750	1.00		72.140	1.66		72.140	1.30		72.140	1.07		72.140	0.73		72.140	0.37	
X=140'	71.972	1.582	0.90	4.80	71.985	1.51	4.75	72.000	1.26	4.17	71.900	0.91	3.80	72.025	0.61	3.11	72.065	0.23	2.54
	71.796	1.406	0.80	4.81	71.785	1.31	4.75	71.890	1.11	4.17	71.700	0.71	3.40	71.925	0.51	3.11	71.985	0.19	2.27
	71.621	1.231	0.70	4.81	71.585	1.11	4.80	71.690	0.91	4.00	71.500	0.51	3.21	71.825	0.41	2.80	71.925	0.15	2.12
	71.446	1.055	0.60	4.75	71.385	0.91	4.47	71.490	0.71	3.93	71.400	0.61	3.11	71.725	0.31	2.86	71.885	0.11	1.97
	71.280	0.879	0.50	4.61	71.185	0.71	4.32	71.270	0.51	3.76	71.300	0.31	2.80	71.685	0.27	2.54	71.865	0.08	1.74
	71.093	0.703	0.40	4.32	70.985	0.51	4.17	71.170	0.41	3.50	71.300	0.27	2.80	71.645	0.23	2.27	71.845	0.07	1.44
	70.917	0.527	0.30	4.00	70.885	0.41	4.01	71.070	0.31	3.40	71.310	0.23	2.80	71.605	0.19	2.12	71.825	0.05	1.37
	70.742	0.352	0.20	3.80	70.785	0.31	3.80	71.030	0.27	3.21	71.270	0.19	2.86	71.565	0.15	1.97	71.805	0.03	0.95
	70.654	0.264	0.15	3.80	70.755	0.27	3.40	70.990	0.23	3.11	71.230	0.15	2.41	71.525	0.11	1.79	71.785	0.01	0.72
	70.566	0.176	0.10	3.31	70.715	0.23	3.31	70.950	0.19	2.80	71.190	0.11	2.12	71.505	0.09	1.80			
	70.478	0.088	0.05	2.41	70.675	0.19	3.00	70.910	0.15	2.86	71.170	0.09	1.79	71.485	0.07	1.30			
	70.390	0.000	0.00		70.635	0.15	2.80	70.870	0.11	2.54	71.150	0.07	1.30	71.465	0.05	1.02			
					70.595	0.11	2.70	70.850	0.09	2.41	71.130	0.05	1.37	71.445	0.03	0.91			
					70.575	0.09	2.41	70.830	0.07	2.12	71.110	0.03	0.91	71.425	0.01	0.95			
					70.555	0.07	2.12	70.810	0.05	1.80	71.090	0.01	0.67						
					70.535	0.05	1.97	70.790	0.03	1.30									
					70.515	0.03	1.30	70.770	0.01	1.13									
					70.495	0.01	1.13												
	Average Velocity			4.26			4.14			3.64			3.03			2.51			2.06

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 9 — Bed Slope= 0.00097 — Temp= 60 F — Rock size= 0.5 in. — Side slope 2:1

Q= 40 cfs — Water Surface Slope= 0.00150 — Thickness= 0.75 in.

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.00'			Location Y=1.00'			Location Y=1.20'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.336	1.901	1.00		72.336	1.93		72.336	1.72		72.336	1.34		72.336	0.90		72.336	0.64	
X=120'	72.137	1.702	0.90	4.01	72.300	1.90	4.00	72.300	1.90	3.60	72.300	1.30	3.31	72.250	0.91	2.80	72.300	0.60	2.54
	71.938	1.503	0.80	4.00	72.120	1.71	4.17	72.130	1.51	3.81	72.110	1.11	3.21	72.000	0.71	2.70	72.210	0.51	2.47
	71.738	1.304	0.70	4.00	71.920	1.51	4.25	71.930	1.31	3.76	71.910	0.91	3.21	71.800	0.51	2.47	72.110	0.41	2.27
	71.540	1.105	0.60	4.00	71.720	1.31	4.25	71.730	1.11	3.76	71.710	0.71	3.06	71.700	0.41	2.41	72.010	0.31	2.20
	71.341	0.906	0.50	3.85	71.520	1.11	4.17	71.530	0.91	3.60	71.510	0.51	3.00	71.600	0.31	2.20	71.970	0.27	2.05
	71.141	0.706	0.40	3.60	71.320	0.91	3.93	71.330	0.71	3.50	71.410	0.41	2.70	71.620	0.27	2.34	71.930	0.23	1.80
	70.942	0.507	0.30	3.40	71.120	0.71	3.76	71.130	0.51	3.50	71.310	0.31	2.86	71.580	0.23	2.06	71.890	0.19	1.70
	70.743	0.308	0.20	3.11	70.920	0.51	3.50	71.030	0.41	3.11	71.270	0.27	2.41	71.540	0.19	1.97	71.850	0.15	1.60
	70.644	0.209	0.15	2.70	70.820	0.41	3.31	70.930	0.31	2.70	71.230	0.23	2.41	71.500	0.15	1.80	71.810	0.11	1.30
	70.544	0.109	0.10	2.54	70.720	0.31	2.88	70.890	0.27	2.86	71.190	0.19	2.12	71.460	0.11	1.30	71.790	0.09	1.13
	70.445	0.100	0.05	1.97	70.680	0.27	2.70	70.850	0.23	2.41	71.150	0.15	1.97	71.440	0.09	1.13	71.770	0.07	0.90
	70.346	0.000	0.00		70.640	0.23	2.66	70.810	0.19	2.12	71.110	0.11	1.27	71.420	0.07	0.80	71.750	0.05	0.80
					70.600	0.19	2.86	70.770	0.15	1.88	71.090	0.09	1.13	71.400	0.05	0.57	71.730	0.03	0.57
					70.560	0.15	2.41	70.730	0.11	0.88	71.070	0.07	0.88	71.380	0.03	0.00	71.710	0.01	0.00
					70.520	0.11	2.12	70.710	0.09	0.57	71.050	0.05	0.57	71.360	0.01	0.00			
					70.500	0.09	1.88	70.690	0.07	0.00	71.030	0.03	0.00						
					70.480	0.07	1.13	70.670	0.05	0.00	71.010	0.01	0.00						
					70.460	0.05	0.00	70.650	0.03	0.00									
					70.440	0.03	0.00	70.630	0.01	0.00									
					70.420	0.01	0.00												
	Average Velocity			3.52			3.63			3.21			2.75			2.27			1.93

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.00'			Location Y=1.00'			Location Y=1.20'		
	72.303	1.958	1.00		72.303	1.87		72.303	1.63		72.303	1.30		72.303	0.97		72.303	0.53	
X=130'	72.107	1.762	0.90	4.01	72.240	1.81	4.01	72.181	1.51	3.60	72.250	1.29	3.31	72.265	0.91	2.80	72.100	0.41	2.41
	71.911	1.566	0.80	4.00	72.140	1.71	4.00	71.981	1.31	3.76	72.130	1.11	3.21	72.065	0.71	2.70	72.000	0.31	2.41
	71.716	1.371	0.70	4.00	71.940	1.51	4.17	71.781	1.11	3.76	71.930	0.91	3.11	71.865	0.51	2.41	72.000	0.27	2.27
	71.540	1.195	0.60	4.01	71.740	1.31	4.17	71.581	0.91	3.50	71.730	0.71	3.00	71.765	0.41	2.41	72.000	0.23	2.12
	71.324	0.979	0.50	3.85	71.540	1.11	4.00	71.381	0.71	3.50	71.530	0.51	2.80	71.665	0.31	2.27	71.980	0.19	1.97
	71.128	0.783	0.40	3.76	71.340	0.91	3.85	71.181	0.51	3.31	71.430	0.41	2.70	71.625	0.27	2.12	71.920	0.15	1.97
	70.932	0.587	0.30	3.50	71.140	0.71	3.76	71.081	0.41	3.11	71.330	0.31	2.54	71.585	0.23	1.97	71.880	0.11	1.79
	70.737	0.392	0.20	3.11	70.940	0.51	3.50	70.981	0.31	2.70	71.290	0.27	2.41	71.525	0.19	1.79	71.860	0.09	1.60
	70.639	0.294	0.15	3.00	70.840	0.41	3.40	70.941	0.27	2.86	71.250	0.23	2.27	71.485	0.15	1.30	71.840	0.07	1.50
	70.541	0.196	0.10	2.70	70.740	0.31	3.00	70.901	0.23	2.66	71.210	0.19	2.27	71.445	0.11	0.80	71.820	0.05	1.30
	70.443	0.098	0.05	2.27	70.700	0.27	2.80	70.861	0.19	2.41	71.170	0.15	1.97	71.425	0.09	0.57	71.800	0.03	1.13
	70.345	0.000	0.00		70.660	0.23	2.70	70.821	0.15	1.97	71.130	0.11	1.80	71.405	0.07	0.44	71.780	0.01	0.80
					70.620	0.19	2.66	70.781	0.11	1.80	71.110	0.09	1.13	71.385	0.05	0.36			
					70.580	0.15	2.41	70.761	0.09	1.60	71.090	0.07	0.80	71.385	0.03	0.36			
					70.540	0.11	2.12	70.741	0.07	1.30	71.070	0.05	0.00	71.365	0.01	0.25			
					70.520	0.09	1.97	70.721	0.05	1.13	71.050	0.03	0.00						
					70.500	0.07	1.70	70.701	0.03	1.13	71.030	0.01	0.00						
					70.480	0.05	1.30	70.681	0.01	0.00									
					70.460	0.03	1.13												
					70.440	0.01	0.00												
	Average Velocity			3.57			3.62			3.34			2.80			2.30			2.05

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.00'			Location Y=1.00'			Location Y=1.20'		
	72.301	1.910	1.00		72.301	1.86		72.301	1.56		72.301	1.30		72.301	0.97		72.301	0.56	
X=140'	72.100	1.727	0.90	4.25	72.175	1.71	4.25	72.255	1.51	3.76	72.225	1.31	3.50	72.200	0.91	2.80	72.282	0.51	3.31
	71.917	1.535	0.80	4.17	71.975	1.51	4.17	72.055	1.31	3.76	72.025	1.11	3.50	72.100	0.71	2.80	72.182	0.41	2.86
	71.725	1.343	0.70	4.00	71.775	1.31	4.17	71.855	1.11	3.76	71.825	0.91	3.40	71.900	0.51	2.66	72.082	0.31	2.54
	71.533	1.151	0.60	4.00	71.575	1.11	4.00	71.655	0.91	3.50	71.625	0.71	3.21	71.800	0.41	2.41	72.002	0.27	2.41
	71.342	0.959	0.50	4.01	71.375	0.91	3.85	71.455	0.71	3.40	71.425	0.51	3.00	71.700	0.31	2.27	71.962	0.23	2.27
	71.150	0.768	0.40	3.85	71.175	0.71	3.76	71.255	0.51	3.31	71.325	0.41	2.80	71.700	0.27	2.12	71.922	0.19	1.97
	70.958	0.576	0.30	3.50	70.975	0.51	3.50	71.155	0.41	3.21	71.225	0.31	2.70	71.660	0.23	2.12	71.882	0.15	1.79
	70.766	0.384	0.20	3.40	70.875	0.41	3.31	71.055	0.31	3.11	71.185	0.27	2.54	71.620	0.19	1.97	71.842	0.11	1.60
	70.670	0.288	0.15	3.21	70.775	0.31	3.11	71.015	0.31	2.70	71.145	0.23	2.54	71.580	0.15	1.79	71.822	0.09	1.30
	70.574	0.192	0.10	2.80	70.735	0.27	3.00	70.975	0.23	2.54	71.105	0.19	2.41	71.540	0.11	1.80	71.802	0.07	1.24
	70.478	0.096	0.05	2.54	70.695	0.23	2.80	70.935	0.19	2.54	71.065	0.15	2.41	71.520	0.09	1.30	71.782	0.05	0.76
	70.382	0.000	0.00		70.655	0.19	2.70	70.895	0.15	2.27	71.025	0.11	2.12	71.500	0.07	1.13	71.762	0.03	0.57
					70.615	0.15	2.66	70.855	0.11	1.97	71.005	0.09	1.79	71.480	0.05	1.13	71.762	0.01	0.57
					70.575	0.11	2.41	70.835	0.09	1.70	70.985	0.07	1.30	71.460	0.03	0.80			
					70.555	0.09	2.12	70.815	0.07	1.30	70.965	0.05	1.13	71.440	0.01	0.00			
					70.535	0.07	1.79	70.795	0.05	1.13	70.945	0.03	1.13						
					70.515	0.05	1.60	70.775	0.03	1.13	70.925	0.01	0.80						
					70.495	0.03	1.30	70.755	0.01	0.80									
					70.475	0.01	1.30												
	Average Velocity			3.70			3.66			3.25			2.90			2.32			2.20

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 10 — Q= 30 cfs

Bed Slope= 0.00146 — Water Surface Slope= 0.00042

Temp= 60 F

Rock size= 0.5 in. — Thickness= 0.75 in.

Side slope 2:1

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.00'			Location Y=1.90'			Location Y=1.20'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.011	1.621	1.00		72.011	1.56		72.011	1.27		72.011	0.90		72.011	0.52		72.011	0.30	
X=120'	71.849	1.459	0.90	4.17	71.900	1.51	3.85	71.900	1.16	3.40	71.945	0.91	2.80	71.950	0.46	2.54	71.940	0.23	1.79
	71.687	1.297	0.80	4.25	71.700	1.31	4.01	71.800	1.11	3.40	71.745	0.71	2.66	71.900	0.41	2.41	71.900	0.19	1.62
	71.520	1.130	0.70	4.17	71.500	1.11	3.93	71.650	0.91	3.31	71.545	0.51	2.54	71.800	0.31	2.27	71.860	0.15	1.52
	71.363	0.973	0.60	4.17	71.300	0.91	3.93	71.450	0.71	3.31	71.445	0.41	2.27	71.760	0.27	2.12	71.820	0.11	1.32
	71.201	0.811	0.50	4.01	71.100	0.71	3.76	71.250	0.51	3.11	71.365	0.31	2.12	71.720	0.23	2.12	71.800	0.08	1.16
	71.038	0.648	0.40	3.85	70.900	0.51	3.50	71.150	0.41	3.00	71.305	0.27	2.27	71.680	0.19	2.12	71.780	0.07	1.02
	70.876	0.486	0.30	3.76	70.800	0.41	3.31	71.000	0.31	2.78	71.265	0.23	1.97	71.640	0.15	1.97	71.760	0.05	0.95
	70.714	0.324	0.20	3.50	70.700	0.31	3.11	71.010	0.27	2.70	71.225	0.19	1.70	71.600	0.11	1.79	71.740	0.03	0.88
	70.633	0.243	0.15	3.21	70.720	0.27	2.80	70.970	0.23	2.85	71.185	0.15	1.60	71.580	0.08	1.79	71.720	0.01	0.80
	70.552	0.162	0.10	3.00	70.620	0.23	2.80	70.930	0.19	2.85	71.145	0.11	1.30	71.560	0.07	1.30			
	70.471	0.081	0.05	2.76	70.640	0.19	2.70	70.890	0.15	2.41	71.125	0.08	1.13	71.540	0.05	0.95			
	70.390	0.000	0.00		70.600	0.15	2.54	70.850	0.11	2.27	71.105	0.07	0.80	71.520	0.03	0.80			
					70.560	0.11	2.27	70.830	0.08	2.12	71.085	0.05	0.72	71.500	0.01	0.80			
					70.540	0.08	2.12	70.810	0.07	1.97	71.065	0.03	0.76						
					70.520	0.07	1.79	70.790	0.05	1.79	71.045	0.01	0.67						
					70.500	0.05	1.60	70.770	0.03	1.60									
					70.480	0.03	1.13	70.750	0.01	1.30									
					70.400	0.01	0.87												
	Average Velocity			3.77			3.40			3.01			2.26			2.02			1.30
	71.971	1.627	1.00		71.971	1.50		71.971	1.20		71.971	0.87		71.971	0.55		71.971	0.22	
X=130'	71.808	1.464	0.90	4.25	71.865	1.51	4.01	71.900	1.19	3.40	71.900	0.80	2.80	71.935	0.51	2.85	71.900	0.15	1.37
	71.646	1.302	0.80	4.17	71.765	1.31	4.08	71.820	1.11	3.40	71.810	0.71	2.54	71.835	0.41	2.41	71.860	0.11	1.08
	71.483	1.139	0.70	4.25	71.565	1.11	4.08	71.620	0.91	3.31	71.610	0.51	2.41	71.735	0.31	2.27	71.840	0.08	0.91
	71.320	0.976	0.60	4.32	71.365	0.91	3.93	71.420	0.71	3.21	71.510	0.41	2.27	71.695	0.27	2.12	71.820	0.07	0.88
	71.158	0.814	0.50	4.17	71.165	0.71	3.80	71.220	0.51	2.80	71.410	0.31	2.12	71.655	0.23	2.12	71.800	0.05	0.76
	70.995	0.651	0.40	4.01	70.965	0.51	3.40	71.120	0.41	2.80	71.370	0.27	2.27	71.615	0.19	1.97	71.780	0.03	0.67
	70.832	0.488	0.30	3.80	70.865	0.41	3.11	71.020	0.31	2.80	71.330	0.23	2.12	71.575	0.15	1.79	71.760	0.01	0.57
	70.669	0.325	0.20	3.50	70.765	0.31	2.88	70.980	0.27	2.54	71.290	0.19	2.12	71.535	0.11	1.60			
	70.588	0.244	0.15	3.21	70.665	0.27	2.80	70.940	0.23	2.54	71.250	0.15	1.97	71.515	0.08	1.30			
	70.507	0.163	0.10	2.80	70.625	0.23	2.80	70.900	0.19	2.27	71.210	0.11	1.79	71.495	0.07	1.30			
	70.425	0.081	0.05	2.54	70.585	0.19	2.54	70.860	0.15	2.12	71.190	0.08	1.60	71.475	0.05	1.13			
	70.344	0.000	0.00		70.545	0.15	2.27	70.820	0.11	1.79	71.170	0.07	1.60	71.455	0.03	0.72			
					70.505	0.11	1.97	70.800	0.08	1.60	71.150	0.05	1.30	71.435	0.01	0.62			
					70.465	0.08	1.79	70.780	0.07	1.30	71.130	0.03	1.13						
					70.465	0.07	1.30	70.760	0.05	1.13	71.110	0.01	0.80						
					70.445	0.05	1.13	70.740	0.03	0.80									
					70.425	0.03	1.13	70.720	0.01	0.80									
					70.405	0.01	1.13												
	Average Velocity			3.79			3.46			2.87			2.25			2.01			1.03
	71.975	1.616	1.00		71.975	1.40		71.975	1.21		71.975	0.92		71.975	0.51		71.975	0.23	
X=140'	71.814	1.454	0.90	4.40	71.900	1.41	4.01	71.870	1.11	3.50	71.960	0.86	3.00	71.875	0.41	2.85	71.935	0.19	1.60
	71.652	1.293	0.80	4.40	71.800	1.31	4.01	71.670	0.91	3.31	71.770	0.71	2.78	71.775	0.31	2.65	71.895	0.15	1.30
	71.491	1.131	0.70	4.32	71.600	1.11	4.01	71.470	0.71	3.21	71.570	0.51	2.65	71.735	0.27	2.41	71.855	0.11	1.13
	71.329	0.970	0.60	4.25	71.400	0.91	4.01	71.270	0.51	3.11	71.470	0.41	2.54	71.695	0.23	2.27	71.835	0.08	1.00
	71.168	0.808	0.50	4.17	71.200	0.71	3.85	71.170	0.41	3.00	71.370	0.31	2.41	71.655	0.19	2.12	71.815	0.07	0.91
	71.006	0.646	0.40	3.85	71.000	0.51	3.80	71.070	0.31	2.80	71.330	0.27	2.54	71.615	0.15	1.97	71.795	0.05	0.84
	70.845	0.485	0.30	3.80	70.900	0.41	3.50	71.030	0.27	2.85	71.290	0.23	2.54	71.575	0.11	1.97	71.775	0.03	0.67
	70.683	0.323	0.20	3.50	70.800	0.31	3.40	70.990	0.23	2.85	71.250	0.19	2.41	71.555	0.08	1.60	71.755	0.01	0.62
	70.602	0.242	0.15	3.11	70.760	0.27	3.21	70.950	0.19	2.41	71.210	0.15	2.12	71.535	0.07	1.60			
	70.522	0.162	0.10	2.78	70.720	0.23	2.80	70.910	0.15	2.27	71.170	0.11	1.80	71.515	0.05	1.30			
	70.441	0.081	0.05	1.97	70.680	0.19	2.70	70.870	0.11	2.12	71.150	0.08	1.30	71.495	0.03	1.30			
	70.360	0.000	0.00		70.640	0.15	2.85	70.840	0.08	1.97	71.130	0.07	1.13	71.475	0.01	1.13			
					70.600	0.11	2.54	70.820	0.07	1.79	71.110	0.05	1.13						
					70.580	0.08	2.41	70.810	0.05	1.60	71.090	0.03	0.80						
					70.560	0.07	2.27	70.790	0.03	1.13	71.070	0.01	0.51						
					70.540	0.05	2.12	70.770	0.01	0.80									
					70.520	0.03	1.79												
					70.500	0.01	1.13												
	Average Velocity			3.78			3.08			2.95			2.44			2.21			1.14

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 11
Q= 30 cfs

Bed Slope= 0.00191
Water Surface Slope= 0.00234

Temp= 68 F

Rock size= 0.5 in.
Thickness= 0.75 in.

Side slope 2:1

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.60'			Location Y=1.90'			Location Y=1.20'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.942	1.557	1.00		71.942	1.40		71.942	1.19		71.942	0.85		71.942	0.49		71.942	0.18	
X=120'	71.786	1.401	0.90	4.61	71.870	1.41	4.17	71.882	1.11	3.60	71.902	0.81	2.80	71.860	0.41	2.54	71.915	0.15	1.60
	71.630	1.245	0.80	4.61	71.770	1.31	4.32	71.682	0.91	3.50	71.802	0.71	2.70	71.760	0.31	2.41	71.875	0.11	1.30
	71.475	1.090	0.70	4.60	71.570	1.11	4.32	71.482	0.71	3.40	71.602	0.51	2.54	71.720	0.27	2.27	71.855	0.09	1.30
	71.319	0.934	0.60	4.61	71.370	0.91	4.17	71.282	0.51	3.31	71.502	0.41	2.54	71.680	0.23	2.12	71.835	0.07	1.13
	71.163	0.778	0.50	4.54	71.170	0.71	3.93	71.182	0.41	3.11	71.402	0.31	2.41	71.640	0.19	2.12	71.815	0.05	0.95
	71.008	0.623	0.40	4.40	70.970	0.51	3.76	71.082	0.31	3.00	71.362	0.27	2.41	71.600	0.15	1.79	71.795	0.03	0.76
	70.852	0.467	0.30	4.01	70.870	0.41	3.60	71.022	0.27	3.00	71.322	0.23	2.41	71.560	0.11	1.79	71.775	0.01	0.72
	70.696	0.311	0.20	3.80	70.770	0.31	3.40	70.982	0.23	2.80	71.282	0.19	2.27	71.540	0.09	1.60			
	70.619	0.234	0.15	3.40	70.730	0.27	3.50	70.942	0.19	2.70	71.242	0.15	2.12	71.520	0.07	1.30			
	70.541	0.156	0.10	3.00	70.690	0.23	3.31	70.902	0.15	2.66	71.202	0.11	1.97	71.500	0.05	1.13			
	70.463	0.078	0.05	2.54	70.650	0.19	3.00	70.862	0.11	2.54	71.182	0.09	1.79	71.480	0.03	1.13			
	70.385	0.000	0.00		70.610	0.15	2.70	70.842	0.09	2.27	71.162	0.07	1.60	71.460	0.01	0.80			
					70.570	0.11	2.66	70.822	0.07	2.12	71.142	0.05	1.30						
					70.550	0.09	2.41	70.802	0.05	1.97	71.122	0.03	1.13						
					70.530	0.07	2.27	70.782	0.03	1.79	71.102	0.01	0.80						
					70.510	0.05	2.12	70.762	0.01	1.30									
					70.490	0.03	1.97												
					70.470	0.01	1.30												
	Average Velocity			4.10			3.77			3.17			2.30			2.04			1.10
	71.914	1.574	1.00		71.914	1.48		71.914	1.28		71.914	0.83		71.914	0.49		71.914	0.17	
X=130'	71.757	1.417	0.90	4.61	71.900	1.47	4.00	71.820	1.11	3.50	71.875	0.79	3.11	71.835	0.41	2.66	71.890	0.15	1.19
	71.600	1.260	0.80	4.61	71.742	1.31	4.25	71.620	0.91	3.50	71.795	0.71	2.80	71.735	0.31	2.54	71.850	0.11	0.95
	71.442	1.102	0.70	4.61	71.542	1.11	4.25	71.420	0.71	3.40	71.595	0.51	2.66	71.695	0.27	2.41	71.830	0.09	0.91
	71.285	0.945	0.60	4.47	71.342	0.91	4.17	71.220	0.51	3.21	71.495	0.41	2.54	71.655	0.23	2.27	71.810	0.07	0.80
	71.127	0.787	0.50	4.47	71:142	0.71	4.00	71.120	0.41	3.21	71.395	0.31	2.54	71.615	0.19	2.12	71.790	0.05	0.62
	70.970	0.630	0.40	4.32	70.942	0.51	3.76	71.020	0.31	3.00	71.355	0.27	2.41	71.575	0.15	1.97	71.770	0.03	0.57
	70.812	0.472	0.30	4.00	70.842	0.41	3.50	70.980	0.27	2.70	71.315	0.23	2.27	71.535	0.11	1.79	71.750	0.01	0.57
	70.655	0.315	0.20	3.93	70.742	0.31	3.40	70.940	0.23	2.54	71.275	0.19	2.12	71.515	0.09	1.52			
	70.576	0.236	0.15	3.50	70.702	0.27	3.31	70.900	0.19	2.41	71.235	0.15	1.97	71.495	0.07	1.16			
	70.497	0.157	0.10	3.21	70.662	0.23	3.11	70.860	0.15	2.12	71.195	0.11	1.79	71.475	0.05	0.80			
	70.419	0.079	0.05	2.54	70.622	0.19	2.80	70.820	0.11	1.97	71.175	0.09	1.60	71.455	0.03	0.67			
	70.340	0.000	0.00		70.582	0.15	2.54	70.800	0.09	1.79	71.155	0.07	1.30	71.435	0.01	0.62			
					70.542	0.11	2.41	70.780	0.07	1.60	71.135	0.05	1.13						
					70.522	0.09	2.41	70.760	0.05	1.13	71.115	0.03	1.05						
					70.502	0.07	2.12	70.740	0.03	0.90	71.095	0.01	0.84						
					70.482	0.05	1.97	70.720	0.01	0.72									
					70.462	0.03	1.60												
					70.442	0.01	1.13												
	Average Velocity			4.11			3.72			3.04			2.41			2.08			0.83
	71.932	1.572	1.00		71.932	1.48		71.932	1.28		71.932	0.84		71.932	0.50		71.932	0.20	
X=140'	71.775	1.415	0.90	4.75	71.900	1.41	4.32	71.865	1.11	3.76	71.800	0.71	3.00	71.840	0.41	2.80	71.865	0.15	1.19
	71.618	1.258	0.80	4.75	71.700	1.31	4.32	71.665	0.91	3.50	71.600	0.51	2.80	71.740	0.31	2.70	71.845	0.11	0.90
	71.460	1.100	0.70	4.61	71.500	1.11	4.32	71.465	0.71	3.50	71.500	0.41	2.66	71.700	0.27	2.54	71.825	0.09	0.91
	71.303	0.943	0.60	4.75	71.300	0.91	4.17	71.265	0.51	3.31	71.400	0.31	2.54	71.660	0.23	2.41	71.805	0.07	0.80
	71.146	0.786	0.50	4.61	71.100	0.71	4.00	71.165	0.41	3.11	71.300	0.27	2.41	71.620	0.19	2.27	71.785	0.05	0.62
	70.989	0.629	0.40	4.47	70.900	0.51	3.85	71.065	0.31	3.00	71.320	0.23	2.27	71.580	0.15	2.12	71.765	0.03	0.36
	70.832	0.472	0.30	4.00	70.800	0.41	3.50	71.005	0.27	2.70	71.280	0.19	2.27	71.540	0.11	1.97	71.745	0.01	0.36
	70.674	0.314	0.20	3.80	70.700	0.31	3.50	70.985	0.23	2.66	71.240	0.15	2.12	71.520	0.09	1.79			
	70.596	0.236	0.15	3.50	70.720	0.27	3.21	70.925	0.19	2.54	71.200	0.11	1.97	71.500	0.07	1.60			
	70.517	0.157	0.10	3.11	70.680	0.23	3.11	70.885	0.15	2.41	71.180	0.09	1.97	71.480	0.05	1.30			
	70.438	0.079	0.05	2.54	70.640	0.19	3.00	70.865	0.11	1.97	71.160	0.07	1.60	71.460	0.03	1.30			
	70.360	0.000	0.00		70.600	0.15	2.70	70.825	0.09	1.79	71.140	0.05	1.30	71.440	0.01	1.13			
					70.580	0.11	2.41	70.805	0.07	1.60	71.120	0.03	1.30						
					70.540	0.09	2.27	70.785	0.05	1.36	71.100	0.01	1.13						
					70.520	0.07	2.12	70.765	0.03	1.02									
					70.500	0.05	1.79	70.745	0.01	0.36									
					70.480	0.03	1.30												
					70.460	0.01	0.76												
	Average Velocity			4.22			3.77			3.11			2.54			2.30			0.85

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 12 Bed Slope= 0.00240 Temp= 71 F Rock size= 0.5 in. Side slope 2:1
Q= 30 cfs Water Surface Slope= 0.00221 Thickness= 0.75 in.

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.00'			Location Y=1.60'			Location Y=1.20'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.000	1.665	1.00		72.000	1.55		72.000	1.33		72.000	0.93		72.000	0.64		72.000	0.28	
X=120'	71.834	1.499	0.90	4.48	71.897	1.45	4.00	71.900	1.23	3.40	71.902	0.83	2.78	71.940	0.57	2.54	71.910	0.19	1.30
	71.667	1.332	0.80	4.40	71.857	1.41	4.17	71.780	1.11	3.31	71.782	0.71	2.86	71.875	0.51	2.41	71.870	0.15	1.13
	71.501	1.166	0.70	4.47	71.757	1.31	4.00	71.580	0.91	3.40	71.582	0.51	2.27	71.775	0.41	2.12	71.830	0.11	0.76
	71.334	0.999	0.60	4.46	71.557	1.11	4.17	71.380	0.71	3.21	71.482	0.41	2.12	71.675	0.31	1.97	71.810	0.09	0.72
	71.168	0.833	0.50	4.32	71.357	0.91	4.17	71.180	0.51	3.11	71.382	0.31	1.97	71.635	0.27	1.97	71.790	0.07	0.62
	71.001	0.666	0.40	4.00	71.157	0.71	3.92	71.080	0.41	2.70	71.342	0.27	1.97	71.595	0.23	1.79	71.770	0.05	0.67
	70.835	0.500	0.30	3.76	70.957	0.51	3.88	70.980	0.31	2.41	71.302	0.23	1.79	71.555	0.19	1.60	71.750	0.03	0.72
	70.668	0.333	0.20	3.50	70.857	0.41	3.90	70.940	0.27	2.27	71.262	0.19	1.70	71.515	0.15	1.30	71.730	0.01	0.60
	70.585	0.250	0.15	3.11	70.757	0.31	3.40	70.900	0.23	1.97	71.222	0.15	1.30	71.475	0.11	1.30			
	70.502	0.167	0.10	2.70	70.717	0.27	3.21	70.860	0.19	1.79	71.182	0.11	1.30	71.455	0.09	1.13			
	70.418	0.083	0.05	1.79	70.677	0.23	3.11	70.820	0.15	1.80	71.162	0.09	1.30	71.435	0.07	0.90			
	70.335	0.000	0.00		70.637	0.19	2.88	70.780	0.11	1.30	71.142	0.07	1.13	71.415	0.05	0.80			
					70.597	0.15	2.54	70.760	0.09	1.30	71.122	0.05	0.80	71.395	0.03	0.76			
					70.557	0.11	2.41	70.740	0.07	0.80	71.102	0.03	0.80	71.375	0.01	0.72			
					70.537	0.09	2.12	70.720	0.05	0.76	71.082	0.01	0.60						
					70.517	0.07	1.80	70.700	0.03	0.76									
					70.497	0.05	1.30	70.680	0.01	0.36									
					70.477	0.03	1.13												
					70.457	0.01	0.51												
	Average Velocity			3.85			3.85			2.01			2.10			1.65			0.90

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.00'			Location Y=1.60'			Location Y=1.20'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.985	1.643	1.00		71.985	1.57		71.985	1.29		71.985	0.99		71.985	0.60		71.985	0.31	
X=130'	71.821	1.479	0.90	4.67	71.900	1.48	4.00	71.905	1.21	3.50	71.905	0.91	2.80	71.890	0.51	2.54	71.910	0.23	1.30
	71.656	1.314	0.80	4.67	71.720	1.31	4.00	71.805	1.11	3.40	71.705	0.71	[illegible]	71.790	0.41	2.41	71.870	0.19	1.13
	71.492	1.150	0.70	4.54	71.520	1.11	4.00	71.605	0.91	3.31	71.505	0.51	2.54	71.690	0.31	2.41	71.830	0.15	1.06
	71.328	0.986	0.60	4.40	71.320	0.91	3.93	71.405	0.71	3.31	71.405	0.41	2.41	71.650	0.27	2.12	71.790	0.11	0.91
	71.163	0.821	0.50	4.25	71.120	0.71	3.76	71.205	0.51	3.00	71.305	0.31	2.27	71.610	0.23	1.97	71.770	0.09	0.72
	70.999	0.657	0.40	4.17	70.920	0.51	3.90	71.105	0.41	2.80	71.265	0.27	2.27	71.570	0.19	1.79	71.750	0.07	0.44
	70.835	0.493	0.30	4.00	70.820	0.41	3.40	71.005	0.31	2.70	71.225	0.23	1.97	71.530	0.15	1.60	71.730	0.05	0.51
	70.671	0.329	0.20	3.85	70.720	0.31	3.21	70.965	0.27	2.80	71.185	0.19	1.79	71.490	0.11	1.30	71.710	0.03	0.57
	70.588	0.246	0.15	3.50	70.680	0.27	3.11	70.925	0.23	2.65	71.145	0.15	1.60	71.470	0.09	1.13	71.690	0.01	0.62
	70.506	0.164	0.10	3.00	70.640	0.23	2.70	70.885	0.19	2.54	71.105	0.11	1.30	71.450	0.07	0.91			
	70.424	0.082	0.05	2.05	70.600	0.19	2.65	70.845	0.15	2.27	71.085	0.09	1.13	71.430	0.05	0.72			
	70.342	0.000	0.00		70.560	0.15	2.06	70.805	0.11	2.12	71.065	0.07	0.72	71.410	0.03	0.51			
					70.520	0.11	2.41	70.785	0.09	1.97	71.045	0.05	0.44	71.390	0.01	0.44			
					70.500	0.09	2.27	70.765	0.07	1.80	71.025	0.03	0.51						
					70.480	0.07	1.97	70.745	0.05	1.13	71.005	0.01	0.51						
					70.460	0.05	1.79	70.725	0.03	0.44									
					70.440	0.03	1.00	70.705	0.01	0.57									
					70.430	0.01	1.30												
	Average Velocity			4.01			3.90			2.65			2.20			1.96			0.90

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.00'			Location Y=1.60'			Location Y=1.20'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.999	1.614	1.00		71.999	1.59		71.999	1.25		71.999	1.01		71.999	0.63		71.999	0.28	
X=140'	71.837	1.452	0.90	4.40	71.916	1.51	4.09	71.860	1.17	3.40	71.900	0.91	2.80	71.960	0.58	2.86	71.950	0.23	1.00
	71.676	1.291	0.80	4.40	71.716	1.31	4.00	71.800	1.11	3.40	71.700	0.71	2.70	71.890	0.51	2.54	71.910	0.19	1.30
	71.516	1.130	0.70	4.32	71.516	1.11	4.01	71.600	0.91	3.40	71.500	0.51	2.54	71.790	0.41	2.41	71.870	0.15	1.30
	71.353	0.968	0.60	4.40	71.316	0.91	4.01	71.400	0.71	3.21	71.400	0.41	2.41	71.690	0.31	2.27	71.830	0.11	1.13
	71.192	0.807	0.50	4.25	71.116	0.71	3.80	71.200	0.51	3.11	71.300	0.31	2.27	71.650	0.27	1.97	71.810	0.09	0.80
	71.031	0.646	0.40	4.00	70.916	0.51	3.40	71.100	0.41	3.00	71.260	0.27	2.27	71.610	0.23	1.97	71.790	0.07	0.60
	70.869	0.484	0.30	3.76	70.816	0.41	3.21	71.000	0.31	2.80	71.220	0.23	1.97	71.570	0.19	1.79	71.770	0.05	0.44
	70.708	0.323	0.20	3.50	70.716	0.31	3.11	70.960	0.27	3.21	71.180	0.19	1.79	71.530	0.15	1.60	71.750	0.03	0.36
	70.627	0.242	0.15	3.21	70.676	0.27	2.70	70.920	0.23	2.65	71.140	0.15	1.30	71.490	0.11	1.30	71.730	0.01	0.00
	70.546	0.161	0.10	2.80	70.636	0.23	2.54	70.880	0.19	2.54	71.100	0.11	1.13	71.470	0.09	1.13			
	70.466	0.081	0.05	2.41	70.596	0.19	2.27	70.840	0.15	2.41	71.080	0.09	0.87	71.450	0.07	0.80			
	70.385	0.000	0.00		70.556	0.15	1.97	70.800	0.11	2.27	71.060	0.07	0.36	71.430	0.05	0.62			
					70.516	0.11	1.70	70.780	0.09	2.12	71.040	0.05	0.60	71.410	0.03	0.25			
					70.496	0.09	1.00	70.760	0.07	1.70	71.020	0.03	0.25	71.390	0.01	0.44			
					70.476	0.07	0.80	70.740	0.05	1.79	71.000	0.01	0.25						
					70.456	0.05	0.80	70.720	0.03	1.30									
					70.436	0.03	0.51	70.700	0.01	0.57									
					70.416	0.01	0.60												
	Average Velocity			3.80			3.41			3.01			2.25			1.96			1.00

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 13 Bed Slope= 0.00301 Temp= 71 F Rock size= 0.5 in. Side slope 2:1
Q= 30 cfs Water Surface Slope= 0.00206 Thickness= 0.75 in.

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.60'			Location Y=1.90'			Location Y=1.20'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.878	1.500	1.00		71.870	1.43		71.878	1.15		71.870	0.80		71.878	0.45		71.878	0.12	
X=120'	71.727	1.352	0.90	4.75	71.760	1.31	4.25	71.835	1.11	3.50	71.785	0.71	2.70	71.835	0.41	2.41	71.863	0.11	0.91
	71.577	1.202	0.80	4.81	71.560	1.11	4.32	71.635	0.91	3.50	71.585	0.51	2.66	71.735	0.31	2.41	71.843	0.09	0.84
	71.427	1.052	0.70	4.75	71.360	0.91	4.25	71.435	0.71	3.40	71.485	0.41	2.54	71.695	0.27	2.27	71.823	0.07	0.76
	71.277	0.902	0.60	4.81	71.160	0.71	3.93	71.235	0.51	3.31	71.385	0.31	2.41	71.655	0.23	2.12	71.803	0.05	0.57
	71.126	0.751	0.50	4.80	70.960	0.51	3.86	71.135	0.41	3.11	71.345	0.27	2.27	71.615	0.19	1.97	71.783	0.03	0.44
	70.976	0.601	0.40	4.47	70.860	0.41	3.50	71.035	0.31	3.00	71.305	0.23	2.12	71.575	0.15	1.97	71.763	0.01	0.36
	70.826	0.451	0.30	4.00	70.760	0.31	3.50	70.995	0.27	2.80	71.265	0.19	1.97	71.535	0.11	1.88			
	70.676	0.301	0.20	3.50	70.720	0.27	3.31	70.955	0.23	2.70	71.225	0.15	1.97	71.515	0.09	1.39			
	70.600	0.225	0.15	3.50	70.680	0.23	3.11	70.915	0.19	2.54	71.185	0.11	1.88	71.495	0.07	1.30			
	70.525	0.150	0.10	3.31	70.640	0.19	2.88	70.875	0.15	2.41	71.165	0.09	1.30	71.475	0.05	1.13			
	70.450	0.075	0.05	2.54	70.600	0.15	2.86	70.835	0.11	2.12	71.145	0.07	1.13	71.455	0.03	0.80			
	70.375	0.000	0.00		70.560	0.11	2.41	70.815	0.09	1.79	71.125	0.05	0.80	71.435	0.01	0.67			
					70.540	0.09	2.27	70.795	0.07	1.30	71.105	0.03	0.76						
					70.520	0.07	2.12	70.775	0.05	0.80	71.085	0.01	0.62						
					70.500	0.05	1.79	70.755	0.03	0.00									
					70.480	0.03	1.13	70.735	0.01	0.00									
					70.460	0.01	0.57												
	Average Velocity			4.21			3.72			3.01			2.20			1.88			0.63
	71.865	1.530	1.00		71.865	1.42		71.865	1.15		71.865	0.78		71.865	0.44		71.865	0.11	
X=130'	71.712	1.377	0.90	4.75	71.850	1.41	4.00	71.820	1.11	3.50	71.790	0.71	2.78	71.835	0.41	2.54	71.840	0.08	0.80
	71.559	1.224	0.80	4.81	71.750	1.31	4.17	71.620	0.91	3.50	71.590	0.51	2.54	71.735	0.31	2.41	71.820	0.07	0.62
	71.406	1.071	0.70	4.75	71.550	1.11	4.32	71.420	0.71	3.40	71.490	0.41	2.41	71.695	0.27	2.54	71.800	0.05	0.51
	71.253	0.918	0.60	4.81	71.350	0.91	4.25	71.220	0.51	3.11	71.390	0.31	2.27	71.655	0.23	2.41	71.780	0.03	0.51
	71.100	0.765	0.50	4.54	71.150	0.71	4.01	71.120	0.41	3.00	71.350	0.27	2.12	71.615	0.19	2.12	71.760	0.01	0.51
	70.947	0.612	0.40	4.40	70.950	0.51	3.78	71.020	0.31	2.80	71.310	0.23	1.97	71.575	0.15	1.97			
	70.794	0.459	0.30	4.17	70.850	0.41	3.60	70.980	0.27	2.66	71.270	0.19	1.97	71.535	0.11	1.79			
	70.641	0.306	0.20	3.86	70.750	0.31	3.50	70.940	0.23	2.66	71.230	0.15	1.79	71.515	0.09	1.30			
	70.564	0.229	0.15	3.50	70.710	0.27	3.40	70.900	0.19	2.41	71.190	0.11	1.00	71.495	0.07	1.13			
	70.488	0.153	0.10	3.21	70.670	0.23	3.11	70.860	0.15	2.27	71.170	0.09	1.30	71.475	0.05	0.80			
	70.411	0.076	0.05	2.54	70.630	0.19	3.00	70.820	0.11	2.12	71.150	0.07	1.13	71.455	0.03	0.51			
	70.335	0.000	0.00		70.590	0.15	2.80	70.800	0.09	1.97	71.130	0.05	0.80	71.435	0.01	0.62			
					70.550	0.11	2.66	70.780	0.07	1.79	71.110	0.03	0.67						
					70.530	0.09	2.41	70.760	0.05	1.00	71.090	0.01	0.62						
					70.510	0.07	2.27	70.740	0.03	1.16									
					70.490	0.05	2.12	70.720	0.01	0.44									
					70.470	0.03	1.79												
					70.450	0.01	1.00												
	Average Velocity			4.20			3.75			3.00			2.18			1.90			0.57
	71.870	1.480	1.00		71.870	1.46		71.870	1.14		71.870	0.79		71.870	0.46		71.870	0.15	
X=140'	71.730	1.340	0.90	4.00	71.825	1.41	4.32	71.850	1.11	3.50	71.795	0.71	3.11	71.832	0.41	2.86	71.842	0.11	1.13
	71.581	1.191	0.80	4.85	71.725	1.31	4.40	71.650	0.91	3.50	71.595	0.51	2.70	71.732	0.31	2.86	71.822	0.09	0.80
	71.432	1.042	0.70	4.00	71.525	1.11	4.40	71.450	0.71	3.50	71.495	0.41	2.66	71.692	0.27	2.54	71.802	0.07	0.88
	71.280	0.890	0.60	4.80	71.325	0.91	4.00	71.250	0.51	3.40	71.395	0.31	2.54	71.652	0.23	2.41	71.782	0.05	0.76
	71.134	0.744	0.50	4.08	71.125	0.71	4.00	71.150	0.41	3.31	71.355	0.27	2.41	71.612	0.19	2.27	71.762	0.03	0.87
	70.985	0.595	0.40	4.40	70.925	0.51	3.86	71.050	0.31	3.11	71.315	0.23	2.27	71.572	0.15	2.12	71.742	0.01	0.72
	70.837	0.447	0.30	4.32	70.825	0.41	3.78	71.010	0.27	2.80	71.275	0.19	2.12	71.532	0.11	1.97			
	70.688	0.298	0.20	3.90	70.725	0.31	3.31	70.970	0.23	2.70	71.235	0.15	1.97	71.512	0.09	1.79			
	70.613	0.223	0.15	3.80	70.685	0.27	3.11	70.930	0.19	2.54	71.195	0.11	1.97	71.492	0.07	1.00			
	70.538	0.149	0.10	3.31	70.645	0.23	3.11	70.890	0.15	2.41	71.175	0.09	1.79	71.472	0.05	1.30			
	70.464	0.074	0.05	2.54	70.605	0.19	2.86	70.850	0.11	2.12	71.155	0.07	1.00	71.452	0.03	1.13			
	70.390	0.000	0.00		70.565	0.15	2.41	70.830	0.09	1.79	71.135	0.05	1.30	71.432	0.01	0.80			
					70.525	0.11	2.12	70.810	0.07	1.79	71.115	0.03	1.13						
					70.505	0.09	1.97	70.790	0.05	1.00	71.095	0.01	1.13						
					70.485	0.07	1.79	70.770	0.03	1.13									
					70.465	0.05	1.00	70.750	0.01	0.72									
					70.445	0.03	0.80												
					70.425	0.01	0.00												
	Average Velocity			4.31			3.73			3.13			2.40			2.19			0.82

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 14 — Q= 30 cfs — Bed Slope= 0.00301 — Water Surface Slope= 0.00322 — Temp= 34 F — Rock size= 0.5 in. — Thickness= 0.75 in. — Side slope 2:1

	Location Y=6.00'				Location Y=4.00'			Location Y=3.40'			Location Y=2.80'			Location Y=2.20'			Location Y=1.60'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.850	1.480	1.00		71.850	1.40		71.850	1.15		71.850	0.88		71.850	0.58		71.850	0.29	
X=120'	71.702	1.332	0.90	4.95	71.800	1.35	4.32	71.805	1.11	3.76	71.800	0.84	3.00	71.785	0.51	2.78	71.785	0.23	1.97
	71.554	1.184	0.80	4.95	71.755	1.31	4.40	71.605	0.91	3.68	71.670	0.71	2.80	71.685	0.41	2.54	71.745	0.19	1.79
	71.406	1.036	0.70	5.01	71.555	1.11	4.47	71.405	0.71	3.50	71.470	0.51	2.86	71.585	0.31	2.27	71.705	0.15	1.80
	71.258	0.888	0.60	4.81	71.355	0.91	4.40	71.205	0.51	3.50	71.370	0.41	2.66	71.525	0.27	2.12	71.665	0.11	1.30
	71.110	0.740	0.50	4.75	71.155	0.71	4.17	71.105	0.41	3.31	71.270	0.31	2.41	71.485	0.23	1.97	71.645	0.09	1.38
	70.962	0.592	0.40	4.67	70.955	0.51	3.85	71.005	0.31	3.11	71.230	0.27	2.41	71.445	0.19	1.97	71.625	0.07	1.13
	70.814	0.444	0.30	4.32	70.855	0.41	3.76	70.965	0.27	3.21	71.190	0.23	2.27	71.405	0.15	1.60	71.605	0.05	0.80
	70.666	0.296	0.20	4.00	70.755	0.31	3.50	70.925	0.23	2.80	71.150	0.19	2.12	71.365	0.11	1.38	71.585	0.03	0.82
	70.592	0.222	0.15	3.90	70.715	0.27	3.50	70.885	0.19	2.80	71.110	0.15	1.97	71.345	0.09	1.30	71.565	0.01	0.51
	70.518	0.148	0.10	3.31	70.675	0.23	3.31	70.845	0.15	2.66	71.070	0.11	1.80	71.325	0.07	1.13			
	70.444	0.074	0.05	2.54	70.635	0.19	3.11	70.805	0.11	2.41	71.050	0.09	1.13	71.305	0.05	1.13			
	70.370	0.000	0.00		70.595	0.15	3.00	70.785	0.09	2.27	71.030	0.07	0.80	71.285	0.03	0.67			
					70.555	0.11	2.54	70.765	0.07	1.97	71.010	0.05	0.82	71.265	0.01	0.57			
					70.535	0.09	2.27	70.745	0.05	1.80	70.990	0.03	0.44						
					70.515	0.07	1.97	70.725	0.03	1.13	70.970	0.01	0.62						
					70.495	0.05	1.80	70.705	0.01	0.80									
					70.475	0.03	1.13												
					70.455	0.01	1.13												
	Average Velocity			4.35			3.65			3.25			2.38			2.06			1.46
	71.827	1.477	1.00		71.827	1.37		71.827	1.14		71.827	0.86		71.827	0.56		71.827	0.26	
X=130'	71.679	1.329	0.90	5.01	71.782	1.31	4.32	71.800	1.11	3.76	71.800	0.83	3.11	71.775	0.51	2.78	71.780	0.19	1.79
	71.532	1.182	0.80	5.00	71.582	1.11	4.40	71.600	0.91	3.80	71.680	0.71	3.00	71.675	0.41	2.41	71.740	0.15	1.80
	71.384	1.034	0.70	5.14	71.382	0.91	4.25	71.400	0.71	3.90	71.480	0.51	2.70	71.575	0.31	2.41	71.700	0.11	1.38
	71.236	0.886	0.60	5.01	71.182	0.71	4.25	71.200	0.51	3.40	71.380	0.41	2.56	71.535	0.27	2.27	71.680	0.09	1.30
	71.088	0.739	0.50	4.80	70.982	0.51	3.85	71.100	0.41	3.21	71.280	0.31	2.54	71.495	0.23	2.27	71.660	0.07	1.13
	70.941	0.591	0.40	4.61	70.882	0.41	3.76	71.000	0.31	2.80	71.240	0.27	2.41	71.455	0.19	2.12	71.640	0.05	1.13
	70.793	0.443	0.30	4.25	70.782	0.31	3.50	70.960	0.27	2.80	71.200	0.23	2.27	71.415	0.15	1.79	71.620	0.03	0.76
	70.645	0.295	0.20	4.01	70.722	0.27	3.50	70.920	0.23	3.00	71.160	0.19	2.12	71.375	0.11	1.80	71.600	0.01	0.62
	70.572	0.222	0.15	3.85	70.682	0.23	3.31	70.880	0.19	2.76	71.120	0.15	1.97	71.355	0.09	1.38			
	70.498	0.148	0.10	3.40	70.642	0.19	3.31	70.840	0.15	2.54	71.080	0.11	1.79	71.335	0.07	1.13			
	70.424	0.074	0.05	2.76	70.602	0.15	3.00	70.800	0.11	2.54	71.060	0.09	1.80	71.315	0.05	0.76			
	70.350	0.000	0.00		70.562	0.11	2.70	70.780	0.09	2.27	71.040	0.07	1.30	71.295	0.03	0.51			
					70.542	0.09	2.70	70.760	0.07	2.12	71.020	0.05	1.13	71.275	0.01	0.44			
					70.522	0.07	2.41	70.740	0.05	1.79	71.000	0.03	0.80						
					70.502	0.05	2.27	70.720	0.03	1.80	70.980	0.01	0.76						
					70.482	0.03	1.97	70.700	0.01	1.30									
					70.462	0.01	1.79												
	Average Velocity			4.45			3.85			3.22			2.46			2.06			1.35
	71.840	1.465	1.00		71.840	1.41		71.840	1.15		71.840	0.85		71.840	0.54		71.840	0.29	
X=140'	71.695	1.318	0.90	5.01	71.800	1.37	4.32	71.800	1.11	3.76	71.800	0.81	3.31	71.805	0.51	3.00	71.800	0.26	2.12
	71.540	1.160	0.80	4.65	71.740	1.31	4.67	71.600	0.91	3.65	71.700	0.71	3.11	71.705	0.41	3.00	71.765	0.19	2.12
	71.400	1.016	0.70	5.00	71.540	1.11	4.67	71.400	0.71	3.90	71.500	0.51	2.80	71.605	0.31	2.80	71.705	0.15	1.79
	71.253	0.873	0.60	4.80	71.340	0.91	4.32	71.200	0.51	3.50	71.400	0.41	2.78	71.565	0.27	2.86	71.665	0.11	1.39
	71.113	0.728	0.50	4.75	71.140	0.71	4.17	71.100	0.41	3.40	71.300	0.31	2.56	71.525	0.23	2.54	71.645	0.09	1.39
	70.967	0.582	0.40	4.80	70.940	0.51	3.90	71.000	0.31	3.31	71.260	0.27	2.54	71.485	0.19	2.54	71.625	0.07	1.13
	70.822	0.437	0.30	4.67	70.840	0.41	3.80	70.960	0.27	3.00	71.220	0.23	2.27	71.445	0.15	2.27	71.605	0.05	0.80
	70.676	0.291	0.20	3.80	70.740	0.31	3.40	70.920	0.23	2.80	71.180	0.19	2.41	71.405	0.11	2.12	71.585	0.03	0.51
	70.603	0.218	0.15	3.30	70.700	0.27	3.40	70.880	0.19	2.56	71.140	0.15	2.27	71.385	0.09	1.97	71.565	0.01	0.44
	70.531	0.146	0.10	3.31	70.660	0.23	3.21	70.840	0.15	2.41	71.100	0.11	1.97	71.365	0.07	1.79			
	70.458	0.073	0.05	2.80	70.620	0.19	2.78	70.800	0.11	2.12	71.080	0.09	1.79	71.345	0.05	1.30			
	70.385	0.000	0.00		70.580	0.15	2.78	70.780	0.09	2.12	71.060	0.07	1.80	71.325	0.03	1.13			
					70.540	0.11	2.27	70.760	0.07	1.79	71.040	0.05	1.30	71.305	0.01	0.80			
					70.520	0.09	1.97	70.740	0.05	1.30	71.020	0.03	1.13						
					70.500	0.07	1.80	70.720	0.03	0.80	71.000	0.01	0.80						
					70.480	0.05	1.30	70.700	0.01	0.80									
					70.460	0.03	0.80												
					70.440	0.01	0.67												
	Average Velocity			4.42			3.73			3.26			2.61			2.49			1.54

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 15
Q= 20 cfs

Bed Slope= 0.00301
Water Surface Slope= 0.00295

Temp= 75 F

Rock size= 0.5 in.
Thickness= 0.75 in.

Side slope 2:1

	Location Y=6.00'				Location Y=4.00'			Location Y=3.50'			Location Y=3.00'			Location Y=2.50'			Location Y=2.00'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.512	1.117	1.00		71.512	1.07		71.512	0.87		71.512	0.63		71.512	0.38		71.512	0.13	
X=140'	71.400	1.005	0.90	4.80	71.450	1.01	3.85	71.450	0.81	3.30	71.450	0.57	2.89	71.440	0.31	2.54	71.490	0.11	1.60
	71.289	0.894	0.80	4.75	71.350	0.91	3.85	71.350	0.71	3.31	71.390	0.51	2.78	71.400	0.27	2.54	71.470	0.09	1.39
	71.177	0.782	0.70	4.68	71.150	0.71	3.68	71.150	0.51	3.21	71.290	0.41	2.54	71.360	0.23	2.41	71.450	0.07	1.39
	71.065	0.670	0.60	4.54	70.950	0.51	3.50	71.050	0.41	3.00	71.190	0.31	2.41	71.320	0.19	2.27	71.430	0.05	1.13
	70.954	0.559	0.50	4.40	70.850	0.41	3.31	70.950	0.31	2.89	71.150	0.27	2.27	71.280	0.15	2.27	71.410	0.03	1.13
	70.842	0.447	0.40	4.17	70.750	0.31	3.21	70.910	0.27	2.78	71.110	0.23	2.12	71.240	0.11	1.79	71.390	0.01	1.13
	70.730	0.335	0.03	3.93	70.710	0.27	3.00	70.870	0.23	2.54	71.070	0.19	1.97	71.220	0.09	1.79			
	70.618	0.223	0.20	3.76	70.670	0.23	2.89	70.830	0.19	2.27	71.030	0.15	1.97	71.200	0.07	1.60			
	70.563	0.168	0.15	3.00	70.630	0.19	2.66	70.790	0.15	2.12	70.990	0.11	1.79	71.180	0.05	1.13			
	70.507	0.112	0.10	2.89	70.590	0.15	2.41	70.750	0.11	1.97	70.970	0.09	1.60	71.160	0.03	0.80			
	70.451	0.056	0.05	1.97	70.550	0.11	2.12	70.730	0.09	1.79	70.950	0.07	1.60	71.140	0.01	0.80			
	70.395	6.000	0.00		70.530	0.09	1.97	70.710	0.07	1.39	70.930	0.05	1.39						
					70.510	0.07	1.79	70.690	0.05	1.13	70.910	0.03	1.13						
					70.490	0.05	1.60	70.670	0.03	0.72	70.890	0.01	1.13						
					70.470	0.03	1.39	70.650	0.01	0.76									
					70.450	0.01	1.27												
	Average Velocity			4.05			3.24			2.77			2.25			2.05			1.24

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 16 Bed Slope= 0.00300 Temp= 71 F Rock size= 0.5 in. Side slope 2:1
Q= 20 cfs Water Surface Slope= 0.00400 Thickness= 0.75 in.

	Location Y=6.00'				Location Y=4.00'			Location Y=3.50'			Location Y=3.00'			Location Y=2.50'			Location Y=2.00'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.452	1.072	1.00		71.452	1.01		71.452	0.89		71.452	0.60		71.452	0.38		71.452	0.13	
X=120'	71.345	0.965	0.90	5.28	71.400	0.96	4.81	71.400	0.84	3.40	71.400	0.55	2.80	71.380	0.31	2.41	71.410	0.09	0.80
	71.237	0.857	0.80	5.14	71.350	0.91	4.81	71.273	0.71	3.21	71.360	0.51	2.70	71.340	0.27	2.12	71.390	0.07	0.72
	71.130	0.750	0.70	5.00	71.150	0.71	3.93	71.073	0.51	3.08	71.260	0.41	2.54	71.300	0.23	2.12	71.370	0.05	0.62
	71.023	0.643	0.60	4.95	70.950	0.51	3.76	70.973	0.41	2.80	71.160	0.31	2.27	71.260	0.19	1.97	71.350	0.03	0.57
	70.916	0.536	0.50	4.80	70.850	0.41	3.50	70.873	0.31	2.80	71.120	0.27	2.27	71.220	0.15	1.80	71.330	0.01	0.57
	70.809	0.429	0.40	4.54	70.750	0.31	3.40	70.833	0.27	2.70	71.080	0.23	2.12	71.180	0.11	1.39			
	70.702	0.322	0.30	4.25	70.710	0.27	3.31	70.793	0.23	2.54	71.040	0.19	1.97	71.160	0.09	1.13			
	70.594	0.214	0.20	3.93	70.670	0.23	3.11	70.753	0.19	2.27	71.000	0.15	1.70	71.140	0.07	1.13			
	70.541	0.161	0.15	3.80	70.630	0.19	2.80	70.713	0.15	1.97	70.960	0.11	1.39	71.120	0.05	0.51			
	70.487	0.107	0.10	3.40	70.590	0.15	2.80	70.673	0.11	1.80	70.940	0.09	1.13	71.100	0.03	0.25			
	70.434	0.054	0.05	2.41	70.550	0.11	2.54	70.653	0.09	1.39	70.920	0.07	0.80	71.080	0.01	0.36			
	70.380	0.000	0.00		70.530	0.09	1.97	70.633	0.07	1.13	70.900	0.05	0.51						
					70.510	0.07	1.80	70.613	0.05	0.88	70.880	0.03	0.00						
					70.490	0.05	1.39	70.593	0.03	0.72	70.860	0.01	0.00						
					70.470	0.03	0.88	70.573	0.01	0.57									
					70.450	0.01	0.36												
	Average Velocity			4.41			3.38			2.67			2.65			1.80			0.65

	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.446	1.066	1.00		71.446	1.01		71.446	0.94		71.446	0.65		71.446	0.40		71.446	0.11	
X=130'	71.340	0.960	0.90	5.14	71.350	0.91	4.80	71.380	0.87	3.46	71.400	0.60	3.11	71.360	0.31	2.41	71.410	0.07	0.80
	71.233	0.853	0.80	5.08	71.150	0.71	3.93	71.220	0.71	3.31	71.310	0.51	2.70	71.320	0.27	2.27	71.390	0.05	0.60
	71.126	0.746	0.70	5.01	70.950	0.51	3.85	71.020	0.51	3.00	71.210	0.41	2.54	71.280	0.23	2.12	71.370	0.03	0.62
	71.020	0.640	0.60	4.95	70.850	0.41	3.50	70.920	0.41	2.80	71.110	0.31	2.41	71.240	0.19	1.97	71.350	0.01	0.57
	70.913	0.533	0.50	4.81	70.750	0.31	3.21	70.820	0.31	2.86	71.070	0.27	2.27	71.200	0.15	1.80			
	70.806	0.426	0.40	4.61	70.710	0.27	3.11	70.780	0.27	2.27	71.030	0.23	2.12	71.160	0.11	1.13			
	70.700	0.320	0.30	4.25	70.670	0.23	3.21	70.740	0.23	1.97	70.990	0.19	1.70	71.140	0.09	1.13			
	70.593	0.213	0.20	4.00	70.630	0.19	3.00	70.700	0.19	1.80	70.950	0.15	1.80	71.120	0.07	0.67			
	70.540	0.160	0.15	3.85	70.590	0.15	2.54	70.660	0.15	1.13	70.910	0.11	1.39	71.100	0.05	0.36			
	70.487	0.107	0.10	3.31	70.550	0.11	2.41	70.620	0.11	0.82	70.890	0.09	1.13	71.080	0.03	0.36			
	70.433	0.053	0.05	2.70	70.530	0.09	2.27	70.600	0.09	0.51	70.870	0.07	1.13	71.060	0.01	0.44			
	70.380	0.000	0.00		70.510	0.07	2.12	70.580	0.07	0.44	70.850	0.05	0.90						
					70.490	0.05	1.70	70.560	0.05	0.44	70.830	0.03	0.57						
					70.470	0.03	1.39	70.540	0.03	0.44	70.810	0.01	0.51						
					70.450	0.01	1.13	70.520	0.01	0.44									
	Average Velocity			4.46			3.44			2.52			2.17			1.67			0.67

	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.430	1.054	1.00		71.430	0.97		71.430	0.76		71.430	0.62		71.430	0.31		71.430	0.10	
X=140'	71.334	0.949	0.90	5.14	71.370	0.91	4.25	71.385	0.71	3.40	71.400	0.59	3.31	71.395	0.27	2.54	71.410	0.07	1.39
	71.228	0.843	0.80	5.20	71.170	0.71	4.00	71.285	0.61	3.40	71.320	0.51	3.21	71.355	0.23	2.41	71.390	0.05	1.13
	71.123	0.738	0.70	5.00	70.970	0.51	4.01	71.185	0.51	3.40	71.220	0.41	2.80	71.315	0.19	2.27	71.370	0.03	0.80
	71.018	0.633	0.60	4.95	70.870	0.41	3.76	70.985	0.31	3.21	71.120	0.31	2.54	71.275	0.15	1.97	71.350	0.01	0.76
	70.912	0.527	0.50	4.80	70.770	0.31	3.50	70.945	0.27	3.00	71.080	0.27	2.54	71.235	0.11	1.79			
	70.807	0.422	0.40	4.47	70.730	0.27	3.40	70.905	0.23	2.70	71.040	0.23	2.41	71.215	0.09	1.80			
	70.701	0.316	0.30	4.32	70.690	0.23	3.21	70.865	0.19	2.41	71.000	0.19	2.12	71.195	0.07	1.13			
	70.596	0.211	0.20	4.00	70.650	0.19	2.80	70.825	0.15	2.27	70.960	0.15	1.97	71.175	0.05	0.25			
	70.543	0.158	0.15	3.80	70.610	0.15	2.86	70.785	0.11	1.79	70.920	0.11	1.39	71.155	0.03	0.00			
	70.490	0.105	0.10	3.11	70.570	0.11	2.54	70.765	0.09	1.39	70.900	0.09	1.13	71.135	0.01	0.00			
	70.438	0.053	0.05	2.41	70.550	0.09	2.41	70.745	0.07	1.13	70.880	0.07	0.82						
	70.385	0.000	0.00		70.530	0.07	1.97	70.725	0.05	0.72	70.860	0.05	0.25						
					70.510	0.05	1.80	70.705	0.03	0.44	70.840	0.03	0.00						
					70.490	0.03	1.39	70.685	0.01	0.72	70.820	0.01	0.25						
					70.470	0.01	1.13												
	Average Velocity			4.43			3.36			2.81			2.33			1.73			1.02

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 18 Bed Slope= 0.00197 Temp= 73 F Rock size= 0.5 in. Side slope 2:1
Q= 35 cfs Water Surface Slope= 0.00240 Thickness= 0.75 in.

	Location Y=6.00'				Location Y=4.00'			Location Y=3.40'			Location Y=2.80'			Location Y=2.20'			Location Y=1.00'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.135	1.782	1.00		72.135	1.68		72.135	1.41		72.135	1.21		72.135	0.90		72.135	0.59	
X=120'	71.958	1.586	0.90	4.80	72.050	1.59	4.32	72.035	1.31	3.93	72.040	1.11	3.60	72.050	0.81	2.80	72.080	0.51	2.41
	71.783	1.410	0.80	4.80	71.970	1.51	4.47	71.835	1.11	3.93	71.840	0.91	3.31	71.950	0.71	2.78	71.980	0.41	2.27
	71.607	1.234	0.70	4.61	71.770	1.31	4.47	71.635	0.91	3.85	71.640	0.71	3.11	71.750	0.51	2.85	71.880	0.31	2.12
	71.430	1.057	0.60	4.47	71.570	1.11	4.47	71.435	0.71	3.78	71.440	0.51	2.80	71.650	0.41	2.41	71.820	0.27	1.79
	71.254	0.881	0.50	4.32	71.370	0.91	4.40	71.235	0.51	3.50	71.340	0.41	2.78	71.550	0.31	2.27	71.780	0.23	1.97
	71.078	0.705	0.40	4.25	71.170	0.71	4.17	71.135	0.41	3.59	71.240	0.31	2.85	71.510	0.27	2.27	71.740	0.19	1.79
	70.902	0.529	0.30	4.01	70.970	0.51	4.01	71.035	0.31	3.31	71.200	0.27	2.54	71.470	0.23	2.27	71.700	0.15	1.60
	70.725	0.352	0.20	3.80	70.870	0.41	3.59	70.995	0.27	3.11	71.160	0.23	2.41	71.430	0.19	2.12	71.660	0.11	1.13
	70.637	0.264	0.15	3.59	70.770	0.31	3.40	70.955	0.23	3.00	71.120	0.19	2.27	71.390	0.15	1.97	71.640	0.09	1.13
	70.549	0.176	0.10	3.31	70.730	0.27	3.40	70.915	0.19	3.00	71.080	0.15	1.97	71.350	0.11	1.79	71.620	0.07	0.80
	70.461	0.088	0.05	2.70	70.690	0.23	3.21	70.875	0.15	2.80	71.040	0.11	1.39	71.330	0.09	1.80	71.600	0.05	0.44
	70.373	0.000	0.00		70.650	0.19	3.00	70.835	0.11	2.54	71.020	0.09	0.80	71.310	0.07	1.60	71.580	0.03	0.25
					70.610	0.15	3.00	70.815	0.09	2.41	71.000	0.07	0.67	71.290	0.05	1.39	71.560	0.01	0.00
					70.570	0.11	2.85	70.795	0.07	2.27	70.980	0.05	0.25	71.270	0.03	0.80			
					70.550	0.09	2.54	70.775	0.05	2.27	70.960	0.03	0.25	71.250	0.01	0.67			
					70.530	0.07	2.27	70.755	0.03	2.12	70.940	0.01	0.00						
					70.510	0.05	2.12	70.735	0.01	2.12									
					70.490	0.03	1.79												
					70.470	0.01	1.00												
	Average Velocity			4.10			3.96			3.52			2.73			2.37			1.79
	72.113	1.77	1.00		72.113	1.69		72.113	1.44		72.113	1.15		72.113	0.84		72.113	0.55	
X=130'	71.936	1.59	0.90	4.61	72.085	1.63	4.25	72.080	1.39	3.85	72.070	1.11	3.60	72.080	0.78	3.11	72.075	0.51	2.54
	71.759	1.42	0.80	4.81	71.935	1.51	4.40	71.980	1.31	3.90	71.870	0.91	3.31	71.980	0.71	3.00	71.975	0.41	2.41
	71.581	1.24	0.70	4.80	71.735	1.31	4.47	71.780	1.11	3.85	71.670	0.71	3.21	71.780	0.51	2.85	71.875	0.31	2.41
	71.404	1.06	0.60	4.61	71.535	1.11	4.32	71.580	0.91	3.78	71.470	0.51	3.11	71.680	0.41	2.54	71.835	0.27	2.12
	71.226	0.89	0.50	4.40	71.335	0.91	4.17	71.380	0.71	3.59	71.370	0.41	2.80	71.580	0.31	2.41	71.795	0.23	1.97
	71.049	0.71	0.40	4.32	71.135	0.71	3.93	71.180	0.51	3.31	71.270	0.31	2.85	71.540	0.27	2.12	71.755	0.19	1.97
	70.872	0.53	0.30	4.01	70.935	0.51	3.78	71.080	0.41	3.31	71.230	0.27	2.85	71.500	0.23	2.12	71.715	0.15	1.79
	70.695	0.35	0.20	3.90	70.835	0.41	3.80	70.980	0.31	3.11	71.190	0.23	2.54	71.460	0.19	1.97	71.675	0.11	1.60
	70.606	0.27	0.15	3.40	70.735	0.31	3.59	70.940	0.27	3.00	71.150	0.19	2.54	71.420	0.15	1.80	71.655	0.09	1.39
	70.517	0.18	0.10	3.21	70.695	0.27	3.21	70.900	0.23	2.80	71.110	0.15	2.27	71.380	0.11	1.60	71.635	0.07	1.39
	70.429	0.09	0.05	2.41	70.655	0.23	2.80	70.860	0.19	2.70	71.070	0.11	2.12	71.360	0.09	1.39	71.615	0.05	1.13
	70.340	0.00	0.00		70.615	0.19	2.54	70.820	0.15	2.54	71.050	0.09	1.97	71.340	0.07	1.13	71.595	0.03	1.13
					70.575	0.15	2.27	70.780	0.11	1.97	71.030	0.07	1.79	71.320	0.05	0.80	71.575	0.01	0.80
					70.535	0.11	2.12	70.760	0.09	1.79	71.010	0.05	1.60	71.300	0.03	0.72			
					70.515	0.09	1.79	70.740	0.07	1.60	70.990	0.03	1.13	71.280	0.01	0.62			
					70.495	0.07	1.39	70.720	0.05	1.13	70.970	0.01	0.67						
					70.475	0.05	1.13	70.700	0.03	0.80									
					70.455	0.03	0.80	70.680	0.01	0.57									
					70.435	0.01	0.62												
	Average Velocity			4.07			3.77			3.34			2.80			2.35			2.01
	72.100	1.734	1.00		72.100	1.65		72.100	1.41		72.100	1.18		72.100	0.84		72.100	0.60	
X=140'	71.926	1.561	0.90	4.80	72.060	1.59	4.40	72.080	1.35	3.90	72.062	1.11	3.59	71.980	0.71	3.11	72.023	0.51	2.78
	71.752	1.387	0.80	4.80	71.970	1.51	4.47	71.910	1.21	3.90	71.862	0.91	3.50	71.780	0.51	3.00	71.923	0.41	2.85
	71.580	1.214	0.70	4.75	71.770	1.31	4.47	71.710	1.01	3.85	71.642	0.71	3.40	71.680	0.41	2.78	71.823	0.31	2.54
	71.406	1.041	0.60	4.54	71.570	1.11	4.40	71.510	0.81	3.85	71.442	0.51	3.11	71.580	0.31	2.41	71.783	0.27	2.54
	71.232	0.867	0.50	4.47	71.370	0.91	4.25	71.310	0.61	3.59	71.342	0.41	2.80	71.540	0.27	2.27	71.743	0.23	2.41
	71.060	0.694	0.40	4.32	71.170	0.71	4.17	71.210	0.51	3.31	71.242	0.31	2.78	71.500	0.23	2.12	71.703	0.19	1.97
	70.885	0.520	0.30	4.17	70.970	0.51	3.78	71.110	0.41	3.21	71.202	0.27	2.85	71.460	0.19	1.97	71.663	0.15	1.79
	70.722	0.347	0.20	4.01	70.870	0.41	3.59	70.970	0.27	2.80	71.162	0.23	2.54	71.420	0.15	1.97	71.623	0.11	1.60
	70.635	0.260	0.15	3.59	70.770	0.31	3.59	70.930	0.23	2.80	71.122	0.19	2.27	71.380	0.11	1.97	71.603	0.09	1.39
	70.540	0.173	0.10	3.21	70.730	0.27	3.31	70.890	0.19	2.85	71.082	0.15	1.97	71.360	0.09	1.79	71.583	0.07	1.00
	70.452	0.087	0.05	2.27	70.690	0.23	3.21	70.850	0.15	2.54	71.062	0.11	1.97	71.340	0.07	1.60	71.563	0.05	0.80
	70.375	0.000	0.00		70.650	0.19	2.80	70.810	0.11	2.12	71.022	0.09	1.79	71.320	0.05	1.39	71.543	0.03	0.62
					70.610	0.15	2.85	70.790	0.09	2.12	71.002	0.07	1.39	71.300	0.03	1.13	71.523	0.01	0.62
					70.570	0.11	2.27	70.770	0.07	1.79	70.982	0.05	1.13	71.280	0.01	1.13			
					70.550	0.09	2.12	70.750	0.05	1.39	70.962	0.03	1.13						
					70.530	0.07	2.12	70.730	0.03	1.13	70.942	0.01	0.76						
					70.510	0.05	1.97	70.710	0.01	1.13									
					70.490	0.03	1.80												
					70.470	0.01	1.13												
	Average Velocity			4.14			3.80			3.38			2.86			2.54			2.19

CORPS OF ENGINEERS RIPRAP PROJECT

Run 8 10 | Bed Slope= 0.00251 | Temp= 73 F | Rock size= 0.5 in. | Side slope 2:1
Q= 35 cfs | Water Surface Slope= 0.00250 | | Thickness= 0.75 in.

	Location Y=6.00'				Location Y=4.00'			Location Y=3.40'			Location Y=2.80'			Location Y=2.20'			Location Y=1.00'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.083	1.083	1.00		72.083	1.63		72.083	1.35		72.083	1.06		72.083	0.79		72.083	0.51	
X=120'	71.885	1.515	0.90	5.01	72.085	1.57	4.80	72.000	1.29	4.01	72.000	0.90	3.31	71.985	0.71	2.78	72.000	0.45	2.41
	71.717	1.307	0.80	5.01	71.985	1.51	4.61	71.820	1.11	4.01	71.915	0.91	3.31	71.785	0.51	2.86	71.900	0.41	2.41
	71.540	1.170	0.70	5.00	71.785	1.31	4.75	71.620	0.91	4.00	71.715	0.71	3.21	71.685	0.41	2.27	71.800	0.31	2.27
	71.380	1.016	0.60	5.01	71.585	1.11	4.75	71.420	0.71	3.93	71.515	0.51	3.00	71.585	0.31	2.12	71.820	0.27	1.97
	71.212	0.862	0.50	4.80	71.385	0.91	4.80	71.220	0.51	3.76	71.415	0.41	2.80	71.545	0.27	2.12	71.700	0.23	1.79
	71.083	0.673	0.40	4.75	71.185	0.71	4.40	71.120	0.41	3.50	71.315	0.31	2.80	71.505	0.23	1.97	71.740	0.19	1.79
	70.875	0.505	0.30	4.40	70.985	0.51	4.25	71.020	0.31	3.50	71.275	0.27	2.70	71.465	0.19	1.79	71.700	0.15	1.60
	70.707	0.337	0.20	4.01	70.885	0.41	4.01	70.980	0.27	3.40	71.235	0.23	2.66	71.425	0.15	1.79	71.680	0.11	1.30
	70.623	0.253	0.15	3.85	70.785	0.31	3.88	70.940	0.23	3.11	71.195	0.19	2.41	71.385	0.11	1.80	71.640	0.08	1.13
	70.530	0.160	0.10	3.40	70.765	0.27	3.58	70.900	0.19	3.11	71.155	0.15	2.41	71.365	0.08	1.60	71.620	0.07	1.13
	70.454	0.084	0.05	2.80	70.685	0.23	3.50	70.860	0.15	2.70	71.115	0.11	2.27	71.345	0.07	1.30	71.600	0.05	0.76
	70.370	0.000	0.00		70.625	0.19	3.11	70.820	0.11	2.70	71.085	0.08	2.12	71.325	0.05	1.13	71.500	0.02	0.57
					70.585	0.15	3.00	70.800	0.08	2.54	71.075	0.07	1.97	71.305	0.03	1.13	71.500	0.01	0.51
					70.545	0.11	2.85	70.780	0.07	2.27	71.065	0.05	1.79	71.285	0.01	1.13			
					70.525	0.08	2.41	70.760	0.05	2.12	71.035	0.03	1.30						
					70.505	0.07	2.12	70.740	0.03	1.97	71.015	0.01	1.13						
					70.485	0.05	1.97	70.720	0.01	1.79									
					70.465	0.03	1.30												
					70.445	0.01	0.44												
	Average Velocity			4.40			4.17			3.84			2.07			2.21			1.02
	72.006	1.085	1.00		72.006	1.61		72.006	1.38		72.006	1.06		72.006	0.75		72.006	0.48	
X=130'	71.876	1.535	0.90	5.01	72.000	1.56	4.54	71.900	1.31	4.01	72.010	1.01	3.50	72.005	0.71	3.11	71.900	0.41	2.85
	71.706	1.385	0.80	5.08	71.900	1.51	4.61	71.700	1.11	3.90	71.910	0.91	3.40	71.805	0.51	2.80	71.800	0.31	2.54
	71.537	1.187	0.70	5.00	71.700	1.31	4.75	71.500	0.91	3.85	71.710	0.71	3.21	71.705	0.41	2.86	71.840	0.27	2.54
	71.387	1.017	0.60	5.01	71.500	1.11	4.75	71.300	0.71	3.80	71.510	0.51	3.00	71.605	0.31	2.54	71.800	0.23	2.41
	71.198	0.808	0.50	4.80	71.300	0.91	4.40	71.100	0.51	3.50	71.410	0.41	2.80	71.505	0.27	2.54	71.700	0.19	2.12
	71.028	0.678	0.40	4.81	71.150	0.71	4.25	71.000	0.41	3.50	71.310	0.31	2.70	71.525	0.23	2.41	71.720	0.15	1.97
	70.880	0.500	0.30	4.77	70.900	0.51	3.93	70.900	0.31	3.40	71.270	0.27	2.54	71.485	0.19	2.27	71.680	0.11	1.79
	70.880	0.330	0.20	3.83	70.800	0.41	3.76	70.860	0.27	3.21	71.230	0.23	2.54	71.445	0.15	1.97	71.600	0.08	1.30
	70.804	0.254	0.15	3.76	70.750	0.31	3.50	70.800	0.23	3.00	71.190	0.19	2.41	71.405	0.11	1.97	71.640	0.07	1.13
	70.520	0.170	0.10	3.11	70.710	0.27	3.40	70.800	0.19	2.86	71.150	0.15	2.27	71.385	0.08	1.97	71.620	0.05	0.80
	70.435	0.085	0.05	2.54	70.670	0.23	3.31	70.800	0.15	2.54	71.110	0.11	2.27	71.365	0.07	1.79	71.600	0.03	0.62
	70.350	0.000	0.00		70.630	0.19	3.11	70.700	0.11	2.41	71.080	0.08	1.97	71.345	0.05	1.30	71.500	0.01	0.51
					70.590	0.15	3.00	70.780	0.08	2.12	71.070	0.07	1.79	71.325	0.03	1.13			
					70.550	0.11	2.27	70.740	0.07	1.97	71.050	0.05	1.80	71.305	0.01	0.72			
					70.530	0.08	2.12	70.720	0.05	1.80	71.030	0.03	1.30						
					70.510	0.07	1.97	70.700	0.03	1.30	71.010	0.01	1.30						
					70.490	0.05	1.80	70.680	0.01	0.76									
					70.470	0.03	1.13												
					70.450	0.01	0.80												
	Average Velocity			4.30			4.00			3.45			2.07			2.50			2.07
	72.084	1.000	1.00		72.084	1.62		72.084	1.35		72.084	1.07		72.084	0.70		72.084	0.51	
X=100'	71.887	1.582	0.90	5.00	72.000	1.57	4.61	72.015	1.31	4.00	72.000	1.02	3.50	71.900	0.71	3.11	72.085	0.46	2.70
	71.720	1.385	0.80	5.14	71.985	1.51	4.65	71.815	1.11	4.00	71.800	0.91	3.40	71.700	0.51	2.70	71.985	0.41	2.86
	71.580	1.180	0.70	5.00	71.785	1.31	4.01	71.615	0.91	4.01	71.600	0.71	3.31	71.600	0.41	2.54	71.885	0.31	2.85
	71.385	1.001	0.60	5.01	71.585	1.11	4.75	71.415	0.71	3.93	71.400	0.51	3.21	71.500	0.31	2.41	71.815	0.27	2.54
	71.220	0.865	0.50	4.01	71.385	0.91	4.54	71.215	0.51	3.76	71.300	0.41	3.11	71.540	0.27	2.27	71.775	0.23	2.41
	71.083	0.688	0.40	4.00	71.185	0.71	4.25	71.115	0.41	3.50	71.280	0.31	3.00	71.500	0.23	2.12	71.735	0.19	2.27
	70.885	0.501	0.30	4.54	70.985	0.51	4.01	71.015	0.31	3.40	71.250	0.27	2.80	71.460	0.19	1.97	71.685	0.15	2.12
	70.719	0.384	0.20	4.40	70.885	0.41	3.80	70.975	0.27	3.31	71.210	0.23	2.86	71.420	0.15	1.79	71.665	0.11	1.79
	70.635	0.250	0.15	4.01	70.785	0.31	3.50	70.935	0.23	3.11	71.170	0.19	2.54	71.380	0.11	1.80	71.635	0.08	1.30
	70.582	0.167	0.10	3.08	70.765	0.27	3.31	70.885	0.19	2.80	71.130	0.15	2.41	71.380	0.08	1.30	71.615	0.07	1.13
	70.480	0.083	0.05	3.00	70.685	0.23	3.00	70.855	0.15	2.86	71.080	0.11	1.97	71.340	0.07	1.13	71.595	0.05	0.80
	70.385	0.000	0.00		70.625	0.19	2.70	70.815	0.11	2.41	71.070	0.08	1.79	71.320	0.05	0.80	71.575	0.03	0.51
					70.585	0.15	2.78	70.795	0.08	2.27	71.060	0.07	1.80	71.300	0.03	0.62	71.555	0.01	0.44
					70.545	0.11	2.41	70.775	0.07	2.12	71.030	0.05	1.13	71.280	0.01	0.67			
					70.525	0.08	2.27	70.755	0.05	1.97	71.010	0.03	0.44						
					70.505	0.07	1.97	70.735	0.03	1.30	70.980	0.01	0.35						
					70.485	0.05	1.80	70.715	0.01	0.80									
					70.465	0.03	1.13												
					70.445	0.01	0.67												
	Average Velocity			4.55			4.65			3.00			2.95			2.35			2.16

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 21
Q= 15 cfs

Bed Slope= 0.00400
Water Surface Slope= 0.00375

Temp= 60 F

Rock size= 0.5 in.
Thickness= 0.75 in.

Side slope 2:1

	Location Y=6.00'				Location Y=4.00'			Location Y=3.60'			Location Y=3.20'			Location Y=2.80'			Location Y=2.40'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	71.300	1.000	1.00		71.300	0.86		71.300	0.86		71.300	0.72		71.300	0.49		71.300	0.25	
X=120'	71.200	0.900	0.90	4.17	71.350	0.91	3.00	71.345	0.81	2.70	71.305	0.63	2.27	71.300	0.39	1.79	71.340	0.19	1.39
	71.197	0.897	0.80	4.00	71.150	0.71	2.80	71.245	0.71	2.06	71.185	0.51	2.12	71.220	0.31	1.80	71.300	0.15	1.30
	71.086	0.786	0.70	4.00	70.950	0.51	2.78	71.045	0.51	2.54	71.085	0.41	1.97	71.180	0.27	1.80	71.260	0.11	1.30
	70.985	0.685	0.60	4.01	70.850	0.41	2.78	70.945	0.41	2.27	70.985	0.31	1.79	71.140	0.23	1.80	71.240	0.09	1.13
	70.885	0.585	0.50	3.90	70.750	0.31	2.54	70.845	0.31	2.27	70.945	0.27	1.79	71.100	0.19	1.30	71.220	0.07	1.13
	70.784	0.484	0.40	3.76	70.710	0.27	2.41	70.805	0.27	2.12	70.905	0.23	1.30	71.060	0.15	1.13	71.200	0.05	0.80
	70.683	0.383	0.30	3.50	70.670	0.23	2.27	70.765	0.23	1.97	70.865	0.19	1.13	71.020	0.11	1.13	71.180	0.03	0.72
	70.582	0.282	0.20	3.11	70.630	0.19	2.12	70.725	0.19	1.79	70.825	0.15	0.80	71.000	0.09	1.13	71.160	0.01	0.67
	70.451	0.151	0.15	2.70	70.590	0.15	1.97	70.685	0.15	1.80	70.785	0.11	0.51	70.980	0.07	0.80			
	70.401	0.101	0.10	2.54	70.550	0.11	1.70	70.645	0.11	1.30	70.765	0.09	0.36	70.960	0.05	0.62			
	70.350	0.050	0.05	2.27	70.530	0.09	1.80	70.625	0.09	1.13	70.745	0.07	0.25	70.940	0.03	0.44			
	70.300	0.000	0.00		70.510	0.07	1.30	70.605	0.07	0.80	70.725	0.05	0.25	70.920	0.01	0.44			
					70.490	0.05	1.13	70.585	0.05	0.51	70.705	0.03	0.25						
					70.470	0.03	0.80	70.565	0.03	0.62	70.685	0.01	0.36						
					70.450	0.01	0.57	70.545	0.01	0.67									
	Average Velocity			3.58			2.51			2.16			1.58			1.38			1.16
	71.407	1.045	1.00		71.407	0.96		71.407	0.82		71.407	0.68		71.407	0.48		71.407	0.19	
X=130'	71.303	0.941	0.90	4.01	71.355	0.91	3.17	71.300	0.71	2.06	71.340	0.61	2.15	71.340	0.41	2.15	71.370	0.15	1.00
	71.198	0.836	0.80	4.14	71.155	0.71	3.01	71.190	0.60	2.46	71.240	0.51	2.15	71.240	0.31	1.67	71.330	0.11	1.00
	71.094	0.732	0.70	3.80	70.955	0.51	2.84	71.090	0.50	2.34	71.140	0.41	2.15	71.200	0.27	1.67	71.310	0.09	0.71
	70.989	0.627	0.60	3.75	70.855	0.41	2.85	70.900	0.31	2.34	71.040	0.31	1.93	71.160	0.23	1.67	71.290	0.07	0.45
	70.885	0.523	0.50	3.62	70.755	0.31	2.65	70.860	0.27	2.01	71.000	0.27	1.97	71.120	0.19	1.36	71.270	0.05	0.32
	70.780	0.418	0.40	3.62	70.715	0.27	2.46	70.820	0.23	2.01	70.960	0.23	1.67	71.080	0.15	1.36	71.250	0.03	0.00
	70.676	0.314	0.30	3.47	70.675	0.23	2.24	70.780	0.19	1.74	70.920	0.19	1.36	71.040	0.11	0.96	71.230	0.01	0.32
	70.571	0.209	0.20	3.01	70.635	0.19	2.01	70.740	0.15	1.70	70.880	0.15	1.36	71.020	0.09	0.91			
	70.519	0.157	0.15	2.84	70.595	0.15	1.74	70.700	0.11	1.42	70.840	0.11	0.96	71.000	0.07	0.75			
	70.467	0.105	0.10	2.46	70.555	0.11	1.42	70.680	0.09	1.00	70.820	0.09	0.91	70.980	0.05	0.53			
	70.414	0.052	0.05	2.01	70.535	0.09	1.08	70.660	0.07	0.71	70.800	0.07	0.88	70.960	0.03	0.00			
	70.362	0.000	0.00		70.515	0.07	0.83	70.640	0.05	0.45	70.780	0.05	0.43	70.940	0.01	0.00			
					70.495	0.05	0.83	70.620	0.03	0.32	70.760	0.03	0.53						
					70.475	0.03	0.71	70.600	0.01	0.45	70.740	0.01	0.53						
					70.455	0.01	0.63												
	Average Velocity			3.44			2.50			2.08			1.80			1.43			0.84
	71.429	1.044	1.00		71.429	0.99		71.429	0.86		71.429	0.75		71.429	0.47		71.429	0.33	
X=140'	71.325	0.940	0.90	4.14	71.350	0.91	3.17	71.380	0.81	2.84	71.390	0.71	2.36	71.370	0.41	1.93	71.370	0.27	1.42
	71.220	0.835	0.80	4.01	71.150	0.71	3.01	71.280	0.71	2.46	71.190	0.51	1.93	71.270	0.31	2.15	71.330	0.23	1.42
	71.116	0.731	0.70	3.80	70.950	0.51	2.85	71.080	0.51	2.05	71.090	0.41	1.93	71.230	0.27	1.93	71.290	0.19	1.00
	71.012	0.627	0.60	3.80	70.850	0.41	2.85	70.980	0.41	2.46	70.990	0.31	1.67	71.190	0.23	1.67	71.250	0.15	1.00
	70.907	0.522	0.50	3.76	70.750	0.31	2.46	70.880	0.31	2.34	70.950	0.27	1.36	71.150	0.19	1.67	71.210	0.11	0.71
	70.803	0.418	0.40	[illegible]	70.710	0.27	2.24	70.840	0.27	2.34	70.910	0.23	1.36	71.110	0.15	1.36	71.190	0.09	0.63
	70.698	0.313	0.30	[illegible]	70.670	0.23	2.01	70.800	0.23	2.01	70.870	0.19	0.96	71.070	0.11	0.96	71.170	0.07	0.55
	70.594	0.209	0.20	[illegible]	70.630	0.19	1.74	70.760	0.19	1.70	70.830	0.15	0.75	71.050	0.09	0.96	71.150	0.05	0.45
	70.542	0.157	0.15	2.80	70.590	0.15	1.74	70.720	0.15	1.42	70.790	0.11	0.80	71.030	0.07	0.53	71.130	0.03	0.32
	70.489	0.104	0.10	2.85	70.550	0.11	1.74	70.680	0.11	1.08	70.770	0.09	0.61	71.010	0.05	0.63	71.110	0.01	0.32
	70.437	0.052	0.05	2.34	70.530	0.09	1.42	70.660	0.09	0.84	70.750	0.07	0.43	70.990	0.03	0.00			
	70.385	0.000	0.00		70.510	0.07	1.14	70.640	0.07	0.63	70.730	0.05	0.61	70.970	0.01	0.00			
					70.490	0.05	0.90	70.620	0.05	0.80	70.710	0.03	0.53						
					70.470	0.03	0.95	70.600	0.03	0.60	70.690	0.01	0.53						
					70.450	0.01	0.80	70.580	0.01	0.55									
	Average Velocity			3.40			2.47			2.11			1.57			1.40			0.95

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 22 Bed Slope= 0.00092 Temp= 66 F Rock size= 0.5 in. Side slope 2:1
Q= 40 cfs Water Surface Slope= 0.00150 Thickness= 0.75 in.

	Location Y=6.00'				Location Y=4.00'			Location Y=3.30'			Location Y=2.60'			Location Y=1.90'			Location Y=1.20'		
	Elevation (ft)	Depth Z, ft	Fraction of Depth	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec	Elevation (ft)	Depth Z, ft	Velocity ft/sec
	72.606	2.221	1.00		72.606	2.17		72.606	1.87		72.606	1.52		72.606	1.24		72.606	0.89	
X=140'	72.384	1.999	0.90	3.31	72.550	2.11	3.40	72.550	1.81	3.11	72.550	1.46	2.89	72.550	1.18	2.66	72.530	0.81	2.41
	72.162	1.777	0.80	3.40	72.350	1.91	3.40	72.450	1.71	3.11	72.400	1.31	2.78	72.400	1.11	2.54	72.430	0.71	2.41
	71.940	1.555	0.70	3.31	72.050	1.61	3.40	72.250	1.51	3.21	72.200	1.11	2.78	72.280	0.91	2.41	72.230	0.51	2.27
	71.718	1.333	0.60	3.21	71.950	1.51	3.31	72.050	1.31	3.00	72.000	0.91	2.66	72.080	0.71	2.27	72.130	0.41	1.97
	71.496	1.111	0.50	3.21	71.750	1.31	3.31	71.850	1.11	3.11	71.800	0.71	2.54	71.880	0.51	2.12	72.030	0.31	1.79
	71.273	0.888	0.40	3.00	71.550	1.11	3.21	71.650	0.91	2.78	71.600	0.51	2.41	71.780	0.41	1.97	71.990	0.27	1.79
	71.051	0.666	0.30	3.00	71.350	0.91	3.00	71.450	0.71	2.66	71.500	0.41	2.27	71.680	0.31	1.97	71.950	0.23	1.60
	70.829	0.444	0.20	2.70	71.150	0.71	2.89	71.250	0.51	2.54	71.400	0.31	2.27	71.640	0.27	1.79	71.910	0.19	1.60
	70.718	0.333	0.15	2.54	70.950	0.51	2.66	71.150	0.41	2.54	71.360	0.27	2.12	71.600	0.23	1.79	71.870	0.15	1.39
	70.607	0.222	0.10	2.27	70.850	0.41	2.54	71.050	0.31	2.41	71.320	0.23	2.12	71.560	0.19	1.79	71.830	0.11	1.13
	70.496	0.111	0.05	2.12	70.750	0.31	2.41	71.010	0.27	2.27	71.280	0.19	2.12	71.520	0.15	1.39	71.810	0.09	0.80
	70.385	0.000	0.00		70.710	0.27	2.27	70.970	0.23	2.12	71.240	0.15	1.79	71.480	0.11	1.13	71.790	0.07	0.62
					70.670	0.23	2.27	70.930	0.19	2.12	71.200	0.11	1.79	71.460	0.09	1.13	71.770	0.05	0.36
					70.630	0.19	1.97	70.890	0.15	1.79	71.180	0.09	1.60	71.440	0.07	0.80	71.750	0.03	0.00
					70.590	0.15	1.79	70.850	0.11	1.79	71.160	0.07	1.60	71.420	0.05	0.62	71.730	0.01	0.00
					70.550	0.11	1.60	70.830	0.09	1.60	71.140	0.05	1.39	71.400	0.03	0.00			
					70.530	0.09	1.60	70.810	0.07	1.60	71.120	0.03	1.39	71.380	0.01	0.00			
					70.510	0.07	1.39	70.790	0.05	1.39	71.100	0.01	1.13						
					70.490	0.05	1.13	70.770	0.03	1.13									
					70.470	0.03	0.80	70.750	0.01	1.13									
					70.450	0.01	0.67												
	Average Velocity			2.97			2.93			2.71			2.45			2.05			1.87